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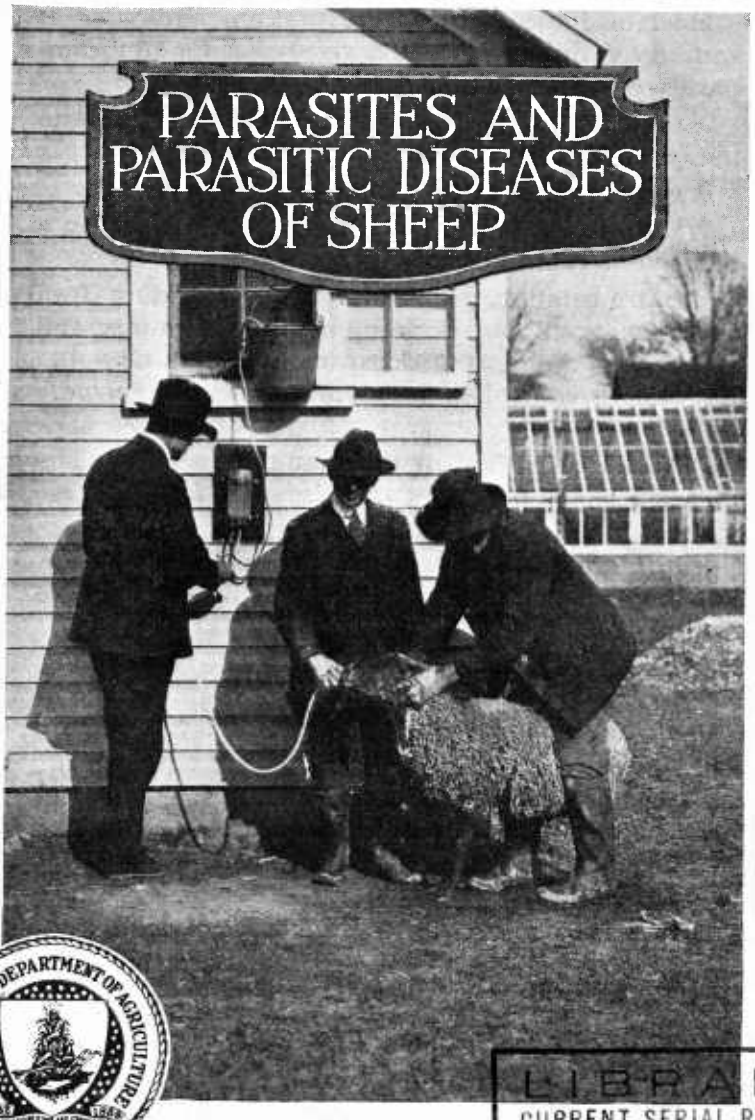
U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1330

PARASITES AND PARASITIC DISEASES OF SHEEP



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SHEEP PROBABLY SUFFER from parasites more than do any other livestock.

Most of the loss in sheep, mutton, and wool is caused by animal parasites, since sheep suffer comparatively little from bacterial diseases.

Lambs and young animals are most susceptible to parasites and suffer most from them.

It is the sheepman's business to *prevent* disease.

When disease is present it is advisable to call in a competent veterinarian.

Pasture rotation, use of forage crops, feeding from racks or bare floors, draining or filling swamps, and restraint of wandering dogs are measures of value in parasitic control. *Permanent pastures perpetuate parasites!*

Parasite eggs pass in the manure, usually. The disposal of the manure determines the fate of these eggs.

Parasitized animals usually do not have fever, but they are unthrifty. This unthriftiness may have a fatal termination.

Act promptly to ascertain the trouble when sheep become unthrifty. A post-mortem examination of one of the sick animals may disclose the trouble and save the others.

This bulletin is a revision of and supersedes Farmers' Bulletin 1150, Parasites and Parasitic Diseases of Sheep.

Washington, D. C.

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PARASITES AND PARASITIC DISEASES OF SHEEP

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CONTENTS

SUSCEPTIBILITY OF SHEEP TO PARASITIC DISEASES

SHEEP are very liable to attack by parasites, probably suffering more severely from this cause than any other kind of livestock. The importance of parasites and parasitic diseases of sheep is the more evident because of the fact that sheep are but little subject to serious bacterial plagues or virus diseases. In this country sheep rarely have tuberculosis, which is one of the serious conditions in cattle and swine, and among sheep there is nothing comparable to the devastating outbreaks of hog cholera among swine. Occasionally a virulent strain of the bacillus producing lip-and-leg ulcer will spread under favorable conditions and necessitate the treatment of entire flocks, or individual sheep will die of pneumonia or other bacterial diseases, but the steady loss of sheep, mutton, and wool from disease in this country is due mostly to parasites.

The damage from parasites is greatest as a rule among lambs and young animals, and it seems to be fairly well established that in general young animals are more easily infected by parasites than older ones, although very old sheep sometimes appear to acquire an increased susceptibility to infection. Hence it is important in undertaking to prevent infestation with parasites to pay especial attention to the care and handling of lambs and yearlings.

[1] Dr. Hall resigned in March 1936 and Dr. Wright in April 1936.

IMPORTANT PREVENTIVE MEASURES

The use of measures intended to prevent sheep from becoming infested with parasites is especially the function of the sheepman. When sheep become diseased, the niceties of diagnosis and the administration of drugs are well within the province of the veterinarian. Errors in diagnosis by unskilled persons waste valuable time and lead to useless or injurious measures. Drugs intended to kill parasites are from the nature of things usually very potent, and are commonly poisonous substances capable of doing much damage in the hands of unskilled or careless persons; therefore, it is usually advisable to secure the services of a competent veterinarian whenever there is an outbreak of disease and a good veterinarian is available. In places where no qualified veterinarians are available, the farmer or stockman must use his own judgment in determining whether he can recognize the trouble and administer the remedy.

One of the most important preventive measures in keeping flocks free from parasites is based on the fact that many of the sheep parasites live in the digestive tract of the sheep or in the organs in communication with the digestive tract, so that the eggs or young worms pass out in the manure and thus infect the pastures. The fact that sheep manure carries worm infestation is the basis of such preventive measures as pasture rotation, rotation of different kinds of stock on the same pasture, feeding from racks or board floors, use of bare lots for nursing lambs, etc.

Another important preventive measure is based on the fact that sheep are the intermediate hosts of some tapeworms of dogs. The bladderworms found in the muscles and in or on the viscera of sheep are the immature stages of tapeworms of dogs. Dogs become infested with the adults of these tapeworms by feeding on uncooked sheep meat or viscera. The tapeworm eggs, when ingested by sheep, develop into bladderworms. For this reason sheep dogs and other dogs on the farm should be kept free from worms and related parasites. Stray dogs should not be permitted to wander over pastures and fields. Another preventive measure is based on the fact that diseases like scab are transmitted by contact with infested animals and places, and clean flocks must be protected from unsafe contacts.

In a general way, the presence of parasites may be suspected as the cause of disease where there is little or no fever, the animals losing condition and becoming thin and commonly having a diarrhea or being constipated. Other features may be associated with certain parasites. Blood-sucking parasites produce anemia, the blood becoming thin and pale as a result of having too few red blood corpuscles for the amount of serum present. Often there is associated with this an edema, in which fluid accumulates in the pendant or lower portions of the body; this is especially noticeable in stomach-worm infestation in sheep, the fluid accumulating under the lower jaw and giving rise to the so-called bottle jaw.

In this connection, the advisability of finding out promptly the cause of the trouble when sheep become diseased should be emphasized. Curtice has stated the case as follows:

> The sheep owner who discovers weakness among his lambs should not wait until one of them dies before he endeavors to make a diagnosis, but should undertake to diagnose the disease in the earlier stages by sacrificing one or

more of the worst affected, and thus gain time in treating and preventing the extension of the disease. By waiting for the disease to develop, he allows the lambs to grow poorer and weaker, and when action is finally undertaken it is upon patients which are, in many cases, already too weak to stand vigorous treatment and which in no way profit by preventive measures as they should.

EXTERNAL PARASITES

External parasites are those which live on the exterior of another animal called the host animal, that is, on the skin or in the layers of the skin or in the hair follicles. Internal parasites are those which live in the body tissues or cavities of the animal that serves as a host.

The external parasites of sheep are all arthropods, or animals having 6 or more legs, some of them being insects, which have 6 legs in the adult stage; others, such as mites and ticks, being more closely related to the spiders and possessing 8 legs in the adult stage. Some of these parasites spend their lives on the sheep; this is true of the scab mites and the lice. These are the important forms. Others, such as various kinds of biting flies, attack sheep occasionally but spend much of their lives off the sheep.

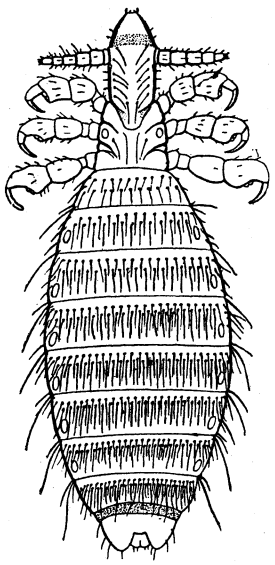

FIGURE 1.—Sucking body louse (*Linognathus ovillus*). Female, dorsal view. Highly magnified. (From Neumann)

LICE[1]

Location.—Lice (*Linognathus ovillus*, *L. pedalis*, *Trichodectes ovis* [=*T. sphaerocephalus*]) live on the skin of sheep, crawling about on the wool or hair and clinging to the wool fibers or hairs in feeding. The sucking body louse (*L. ovillus*) is commonly found in colonies on various parts of the body, including the face. The foot louse (*L. pedalis*) is usually found on the lower portions of the legs, below the true wool and in the short, coarse hair. The biting louse (*T. ovis*) occurs on various parts of the body.

Appearance.—The sucking body louse has a head somewhat longer than the thorax. (Fig. 1.) The abdominal segments bear two rows of long hairs. The male is 2.1 millimeters (about one-twelfth of an inch) long and the female is 2.8 mm. (about one-tenth of an inch) long. There is an inconspicuous eye on each side of the head. The wool in the region attacked by this louse is usually discolored and contains numerous brown particles, the fecal deposits of the lice.

The foot louse has a short head, as wide as it is long, which merges into the thorax, with reddish oblique bands on each side. (Fig. 2.) No eyes are present. The abdominal segments bear two rows of hairs, of which those at the lateral margin are longer than the others. The female is 2.2 mm. (about one-twelfth of an inch) long and 1 mm. (one twenty-fifth of an inch) wide; the male is broader and flatter. This is a sucking louse like the preceding species.

[1] For additional information see Leaflet 13, Sheep and Goat Lice, issued by the U. S. Department of Agriculture.

The biting louse has a head that is wider than long, with a broad, round anterior end. (Fig. 3.) The abdominal segments show a median dark line and have only a single row of hairs. The male is 1.4 mm. (about one-twentieth of an inch) long and the female is 1.6 mm. long.

Life history.—The eggs of the various species of sheep lice are attached to the hair or wool in the sites customarily infested by the adult lice. The eggs of the sucking lice are said to hatch in 10 to 18 days; those of the biting lice in 5 to 8 days ordinarily, or 10 days in cold weather. Available evidence indicates that the young lice become mature and begin laying eggs about two weeks after hatching. The sucking lice, as the name implies, are bloodsuckers. The biting lice feed on the epithelial scales and other material on the surface of the skin. Lice usually cause little trouble in summer, but become more numerous and annoying in winter.

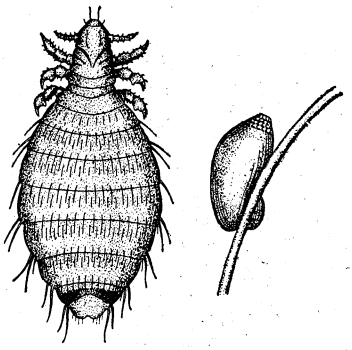

FIGURE 2.—Sheep foot louse (*Linognathus pedalis*). Adult female and egg, enlarged. (From Osborn)

Distribution.—Biting lice are rather common in the United States. The sucking body louse is fairly common on sheep in the Southwest. The foot louse has been found on sheep in various parts of the country.

Symptoms and lesions.—Lice, whether biting lice or sucking lice, cause itching and irritation. This of itself interferes with nutrition, and affected animals fail to fatten or keep in condition as they should. Moreover, the itching leads to scratching, with a resultant loss of wool, and this scratching adds more time lost from feeding to that lost from discomfort. Scratching may also cause cuts and bruises. The loss of nervous energy and the interference with feeding and nutrition tend to stunt the growth of young animals, interfere with the fattening of the entire flock, and predispose to other diseases by lowering the vitality. Actual lesions in the form of sores are caused where numerous biting lice cluster. Where sucking lice are numerous they abstract blood and lymph in considerable quantities. Finally, the excreta of the lice soil the wool, sometimes to a considerable extent; this is particularly true of the sucking body louse.

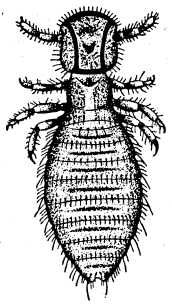

FIGURE 3.—Biting sheep louse (*Trichodectes ovis*). Adult female, enlarged. (After Neumann)

Lice are readily found by examining infested animals carefully, preferably in direct sunlight.

Treatment.—Where sheep are infested with biting lice only, sodium fluoride may be applied in the form of a powder to get rid of them, a single application sufficing for this purpose. The powder is rubbed into the skin at a number of places or may be applied with a dust gun. It is of no value against sucking lice. Sodium fluoride should not be applied to mucous membranes, such as those of the mouth and anus.

For sucking lice it is necessary to use a contact poison, and these poisons are also satisfactory for biting lice. In cold weather, when dipping is inadvisable, insect powders, composed largely of pyrethrum and naphthalene, may be used as a control measure and will serve to control the lice, but are not satisfactory in eradicating them.

For dipping, the substances which have been found effective in field tests are coal-tar creosote, cresol, arsenical dip, and 0.07 per cent nicotine solution. In order to eradicate lice successfully it is usually necessary to dip at least twice, with an interval of 14 to 16 days between dippings, in order to kill the lice that hatch out after dipping, since these dips can not be depended upon to kill all the eggs or "nits." Spraying is generally unsatisfactory as a method of applying dips to sheep, as it is too difficult to wet the wool.

Sheep should be handled carefully, not roughly. Dip the bucks, ewes, and lambs separately. The sheep should be fed and watered from 3 to 6 hours before dipping, in order that they may not be hungry or thirsty and yet not gorged with food. In hot weather they should be cooled off before dipping, and when the nights are cold they should be dipped in time to dry off before night. Ten days should elapse after shearing before dipping, in order that cuts may heal, especially when arsenical dips are used. Because of their extremely poisonous nature it is usually inadvisable to use arsenical dips in treating sheep.

FIGURE 4.—Sheep tick (*Melophagus ovinus*). Engorged female, enlarged. (From Imes)

Prevention.—To prevent infestation with lice it is essential that contact with lousy animals be prevented and that animals free from lice be kept out of sheds, pens, inclosures, or pastures where lousy stock have been within three weeks. After the first dipping, sheep should be put on clean pastures or held in clean inclosures to allow time for any eggs to hatch and the lice to die, or else the sheds and lots should be thoroughly cleaned out and disinfected before being used. For this sort of disinfection the coal-tar dips in double the strength used for dipping are satisfactory.

THE SHEEP TICK[1]

Location.—The sheep tick (*Melophagus ovinus*) occurs in the wool and on the skin.

Appearance.—The sheep tick is not really a tick, but is a kind of wingless fly. (Fig. 4.) It has six legs, whereas the full-grown true ticks have eight legs. The mouth parts are very similar to those of other flies. These insects are reddish or gray-brown in color, and are about a quarter of an inch long on an average, and may therefore be easily distinguished from the lice. They are distinctly divided into

[1] For additional information see Farmers' Bulletin 798, The Sheep Tick.

head, thorax, and abdomen, which distinguishes them from the true ticks, which are occasionally found on sheep, as these true ticks have the thorax and abdomen fused, with the head not conspicuously distinct.

Life history.—The egg of the sheep tick is not laid as such, but is retained in the body of the female until it develops into a larva or pupa, which occurs in about seven days. The pupa is then deposited by the tick and is attached to the wool of the sheep by a gluelike substance. When deposited it is covered with a soft, white membrane, which becomes brown and hard in about 12 hours. The pupae of the sheep tick are commonly called eggs. The young ticks emerge from the pupal stage in 19 to 24 days, shorter time being in warm weather and the longer in cold weather. The tick is almost full grown when it leaves the pupal case and it becomes mature in 3 to 4 days. After copulation the female may deposit its first pupa in 8 to 10 days.

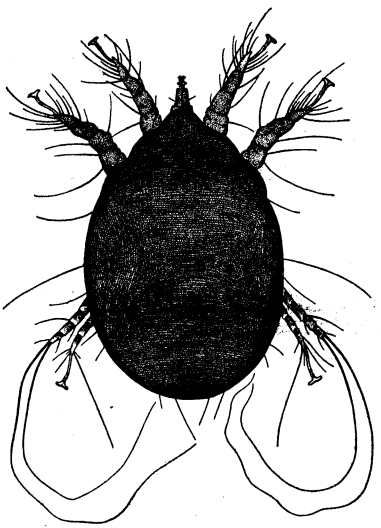

FIGURE 5.—Sheep-scab mite (*Psoroptes communis ovis*). Female. Dorsal view, greatly enlarged. (After Salmon and Stiles).

Distribution.—Sheep ticks are widely distributed over the world and are common in the United States on both farms and ranges. They are most common on coarse-wool and medium-wool sheep, and prefer the neck, breast, shoulders, belly, and thighs.

Symptoms and lesions.—The tick is a bloodsucker, causing great irritation, loss of blood, interference with feeding, and consequently poor nutrition and reduced vitality. It lives in the wool and lowers the value of the wool by soiling it with the excreta and pupal cases. This loss is in addition to the wool deterioration which results from the injury to the sheep itself. The ticks may be found on parting the wool. Their presence may be suspected when sheep bite, scratch, or rub, and show a ragged fleece as a result.

Treatment.—The treatment for ticks is dipping the sheep. The coal-tar creosote, cresol, nicotine, and fused bentonite-sulphur dips are all satisfactory if used according to the manufacturers' directions. Dip the sheep twice, with a 24- to 28-day interval between dippings. Investigations in the Bureau of Animal Industry have likewise shown that dilute derris or cube dips (6 ounces of derris or cube powder containing 5 percent rotenone in 100 gallons of water) possess unusual promise for eradicating ticks by a single dipping.

Prevention.—All places which have been occupied by ticky sheep should be regarded as dangerous for a period of two months, as the pupae may retain their vitality under certain conditions for almost this length of time. Usually pupae remain in the wool, but wool containing pupae may be rubbed off or pulled off, and young ticks hatching from such pupae may afterwards get on the sheep.

Inclosures which are to be used for clean sheep within this period should be thoroughly cleaned and the litter and manure disposed of in such a way that sheep can not come into contact with them until after the 60-day period. A strong solution of coal-tar dip should also be used, but this can not be depended on to kill the pupae, though it is useful in killing the ticks that might escape a cleaning process. To disinfect stone or wire-fence corrals, brush or straw may be scattered over the surface of the ground and burned. Clean sheep must be kept away from contact with ticky sheep, and care must be taken to see that goats or other animals do not convey ticks to the sheep.

SHEEP-SCAB MITE[2]

COMMON SCAB

Location.—On the skin.

Appearance.—These parasites (*Psoroptes communis ovis*) are very small animals, called scab mites. (Fig. 5.) The male is only 0.5 mm. (one-fiftieth of an inch) long and the female 0.625 mm. (one-fortieth of an inch), but they may be seen with the naked eye as small white objects, especially when placed on a dark background. It is easier to see them when they are warmed, by sunlight or otherwise, on such a background, as they may then be in motion. The full-grown mites have 4 pairs of legs and these legs have long hairs. In the female there are so-called suckers on jointed stalks on the tips of the first, second, and fourth pairs of legs, and in the male on the first, second, and third, the fourth pair in the male having a sucker which is not on a jointed stalk.

Life history.—The female mite usually deposits at least 15 eggs during her life, and may deposit 24. In 3 or 4 days these hatch, the young mites beginning life with only 6 legs. In 7 or 8 days these have become 8-legged mites, which mate and begin depositing eggs in the course of the next 3 or 4 days. One investigator (Gerlach) has estimated that in 90 days this rate of reproduction under favorable circumstances, beginning with a single impregnated female, would produce one and one-half million mites.

Distribution.—Scab was formerly widely distributed over the United States, begin the greatest pest that sheepmen had to contend with. Quarantine and eradicative dippings have nearly cleaned it out of the greater part of this country, so that at present it is largely a matter of cleaning up the relatively small amount still scattered about, an exceedingly difficult task, however, because of the scattered infection. The cooperation of individual owners in promptly reporting to local livestock sanitary authorities cases of scab or cases suggestive of scab is highly important in scab eradication.

Symptoms and lesions.—The scab mite pricks the skin and sucks the blood serum. The puncture becomes inflamed, forming a small red spot with a slight exudation of serum. This serum forms the

2 For additional information see Farmers' Bulletin 713, Sheep Scab.

scab, from which the disease takes its name. (Fig. 6.) The watery part of the serum dries out, leaving a small crust over the site of each bite, the aggregate of these bites leading to the formation of rather large crusts or scabs. At the same time the bite causes itching and this in turn leads to scratching, rubbing, and biting, thereby adding to the initial inflammation and producing a certain amount of hemorrhage as the scabs are rubbed off and sores form. The serum and sores afford lodging and favorable conditions for bacteria and become infected. The skin reacts to the continued inflammation and becomes thickened.

The first symptom noticed as a rule is the itching, manifested by a disposition to rub and scratch. The wool is roughened and broken by the scratching, and this condition suggests the possibility of scab. The sheep become restless and spend considerable time biting and rubbing the affected spots, finally losing the wool off large areas and

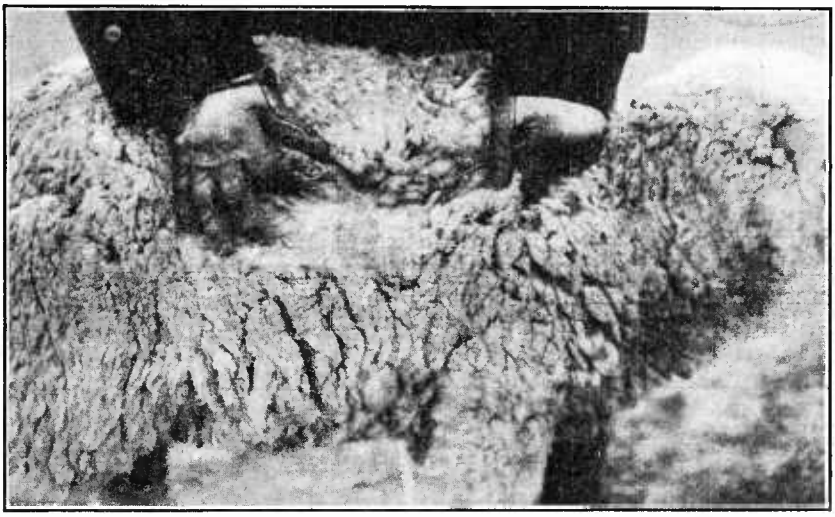

FIGURE 6.—Characteristic scab lesion in early stages of the disease. (From Imes)

leaving scabby sores. (Fig. 7.) The time and energy spent in trying to alleviate itching are time and energy lost from feeding and growing, and this fact shows itself in the poor condition of scabby sheep. Ultimately many of these sheep will die unless treated, and they are always so weakened as readily to fall victims to other diseases.

The diagnosis of this disease is best made by a capable veterinarian, as the disease is too serious to warrant taking any chance on its spread. Itching, loss of wool, and other conditions present in scab may also be shown in the presence of lice, sheep ticks, true ticks, barded seeds, cactus spines, eczema, wildfire, summer sores, rain rot, shear cuts, sunburn, and inflammation of the sebaceous glands; the effects of alkali dust may at times be mistaken for scab.

Treatment.—The only satisfactory treatment for scab is dipping. Hand dressing will not suffice and permits the spread of the disease while seeming to cure obviously affected areas. Animals must be

dipped in a warm dip twice, with an interval of 10 to 14 days, preferably 10, between the dippings. Ewes, bucks, and lambs should be dipped separately. Sheep must be held in the dip not less than two minutes; animals severely affected, especially if fine-wool sheep, should be held three to five minutes the first time, unless the crusts and scabs are first broken up and soaked with dip. The lime-sulphur dip and the nicotine dip are recognized in official dipping for scabies.

Prevention.—Open pasture that has been used by scabby sheep is regarded as dangerous for a month, and buildings are regarded as dangerous for the same length of time. Keep clean sheep away from old bedding grounds and other infected areas for 30 days after infected sheep have been removed from them. Small enclosures which

FIGURE 7.—Scabby buck with entire hindquarters and flank affected. (From Imes.) (The discolored area is due to dip stain from hand dressing)

have been occupied by scabby sheep should be cleaned and disinfected. All litter and manure should be removed and exposed surfaces sprayed with a coal-tar-creosote dip. Protection from reinfection is afforded for 60 days by lime-sulphur dips provided the dip is not washed out by rain or otherwise. Stray sheep should be looked on with suspicion, and goats may carry scab mites for long periods. Care must be used in purchasing sheep from areas where there has been any scab.

OTHER VARIETIES OF SCAB

Head scab and foot scab in sheep are relatively rare diseases caused by species of mites different from those causing common scab. The same methods of treatment may be used, but head scab may prove more difficult to cure and four or five or more dippings, sup-

plemented by local applications of remedies, may be necessary. In cases of head scab the interval between dippings should be shortened to a week or even to five days.

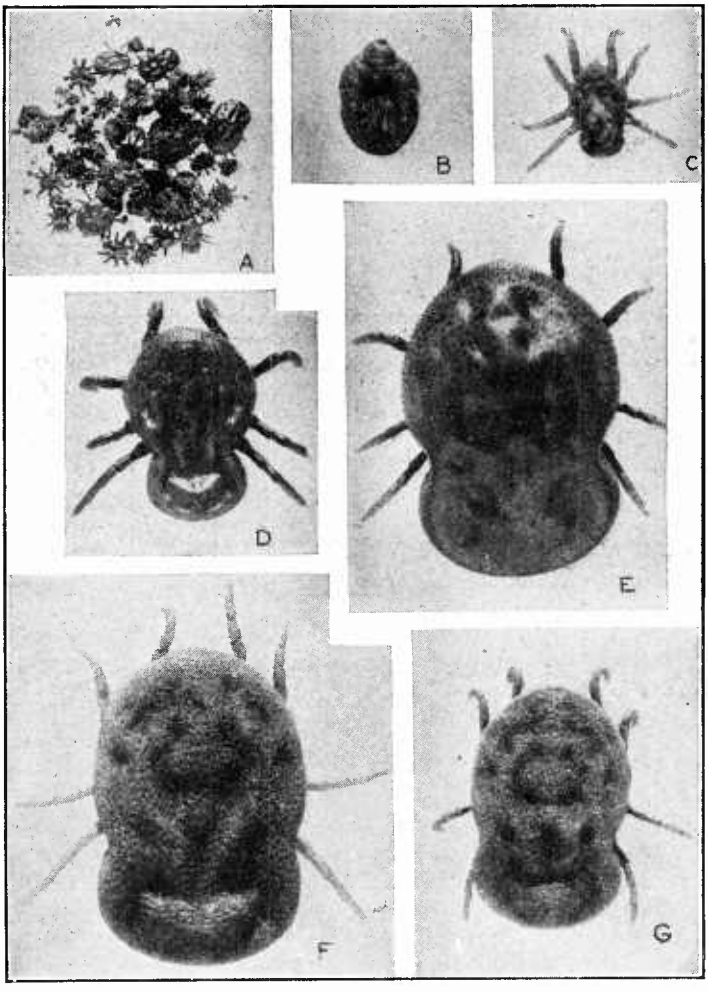

FIGURE 8.—The spinose ear tick (*Otobius mégnini*). *A*, ear ticks and débris from ear of cow (about natural size). *B*, engorged larva (magnified five times). *C*, young tick (magnified five times). *D*, partially engorged young tick (magnified five times). *E*, fully engorged young tick (magnified five times). *F*, adult female (magnified five times). *G*, adult male (magnified five times). (From Imes)

OTHER EXTERNAL PARASITES

True ticks occasionally infest sheep, but in this country it is rare to find ticks present on sheep and we are fortunately free from ticks that habitually infest sheep. Among those that do occur on our

sheep is the spinose ear tick,[3] (*Otobius mégnini* [*Ornithodorus mégnini*]). This is particularly prevalent in the Southwest. It enters the external canal of the ear and attaches there well below the hair line, sucking blood from the tender skin. The ticks enter the ear as 6-legged seed ticks, become engorged, grublike larvae, molt to form the 8-legged nymph, which is covered with numerous small spines, and after months spent in the ear the nymphs crawl out, conceal themselves in dry protected places, transform into adult ticks, and mate. (Fig. 8.) The female lays eggs which give rise to the 6-legged seed ticks and these in turn infest new hosts. Infested animals often have the ear canal plugged with wax and the excretions of the ticks. Such animals shake their heads or turn them from side to side. The ticks cause serious injury and occasionally death, especially among horses and cattle. The best treatment is to clean the ear canal with a wire loop, using care not to injure the animal, and inject into the canal a mixture of 2 parts commercial pine tar and 1 part cottonseed oil.

The screw worms[4] (*Cochliomyia macellaria* and *C. americana*) are the maggots of blowflies that are especially prevalent in the Southwest and South. They are especially apt to infest sheep recently sheared, getting into the fresh cuts, and in the same way to attack sheep and other animals that have been recently castrated, dehorned, or otherwise injured by having the skin broken.

FIGURE 9.—A screw-worm fly, as seen from above. Much enlarged. (From Bishopp, Mitchell, and Parman)

According to entomologists of the Federal Bureau of Entomology and Plant Quarantine, the screw-worm flies (*C. americana* and *C. macellaria*) are bluish-green blowflies with three dark stripes along the back between the wings, and with a yellowish-red face. The yellowish eggs are laid in irregular masses on the edges of wounds or blood spots. The eggs hatch in 10 to 12 hours into small maggots which promptly penetrate the wound, causing bleeding and pain. The maggots destroy the tissues rapidly and enlarge the wound, thus attracting more flies. Finally the vital organs are exposed, or the poisons from the extensive wounds are absorbed, and the animal dies. The maggots become full-grown (about two-thirds of an inch long) in 5 to 6 days, leave the wound or carcass, burrow into the ground, and change into flies 3 to 14 days later.

The two species of screw-worm flies can be distinguished only by a microscopic examination. One species is primarily a parasite of warm-blooded animals and is usually the first to attack. The other

[3] For additional information see Farmers' Bulletin 980. The Spinose Ear Tick and Methods of Treating Infested Animals.

[4] For additional information write to the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Washington, D. C.

species usually invades the wounds a little later, but the two may be present in the same wound. The maggots of certain other blowflies also may be found in wounds and in the soiled wool of sheep. These various blowflies breed in carcasses of dead animals. The number of flies produced depends, largely, on the size of the carcass. It has been estimated that the carcass of a horse or cow will breed about a million flies.

The best treatment for an infested wound is a remedy known as formula (or smear) No. 62. It contains 3½ parts by weight each of diphenylamine and benzol, 1 part turkey red oil, and 2 parts lamp black. This remedy may be obtained ready-mixed. Probing and opening the burrows are regarded as inadvisable. When the wound is severe it is advisable to call in a veterinarian, as there is sometimes serious danger from hemorrhage and infection.

By way of prevention it is essential that carcasses of animals dying from any cause should be promptly burned or otherwise disposed of so that flies can not breed in them. If they are buried they should be buried in quicklime and the entire carcass should be at least two feet under ground and the soil tightly packed. Shearing cuts and other injuries from accident or operations should be coated with pine tar to prevent flyblow. Flytraps are valuable as control measures.

FIGURE 10.—Screw-worm maggot, side view. Enlarged. (From Bishopp, Mitchell, and Parman)

Sheep-wool maggots belonging to a number of species (*Phormia regina*, *Lucilia sericata*, and others) are somewhat similar in habits to the screw-worm fly. Related flies have become a very serious pest to sheep in Australia. The flies deposit their eggs or young in the wool. Infested sheep are sometimes treated by clipping the wool about infested parts and applying concentrated dip, chloroform, or mixtures of turpentine and tar. It is also advised that lambing should occur as early as possible and shearing be carried on before the warm weather sets in, to reduce the chance of infestation. The wool of sheep, especially those affected with diarrhea, should be kept trimmed about the tail region to prevent flyblow at this place. A practice which has been found of considerable value in Australia consists in spraying the tail region of the sheep with 0.7 per cent solution of arsenious oxide just before lambing time. This can be done quickly and easily, is cheap, and affords considerable protection. The prompt destruction of carcasses is as important in the control of these maggots as it is in the control of the screw worm.

INTERNAL PARASITES

The internal parasites include tapeworms, flukes, roundworms, and a few other forms, such as the maggots causing grub in the head, the tongue worm, and the one-celled forms, or Protozoa, these last being microscopic in size and of comparatively little known importance in the United States so far as sheep are concerned.

The following discussion includes the more important of the numerous kinds of internal parasites that infest sheep.

ARTHROPODS

The arthropods include certain forms that live during a portion of their life as internal parasites of sheep, though most of the arthropod parasites of sheep are external parasites.

The arthropods are forms which possess 6 or more leglike appendages, such as the insects, which, in a limited sense of the word, include those forms with 6 legs, the spiders and spiderlike forms, which as adults have 8 legs, and other forms having more than 8 legs, some of them a considerable number.

The life history of the arthropods varies so greatly in the case of different forms that it is hardly possible to give a general statement covering it.

GRUB IN THE HEAD

Location.—The grubs (*Oestrus ovis*) occur in the nostrils and in such communicating cavities as the frontal sinus and the maxillary sinuses, cavities in the upper jawbone.

Appearance.—The parasites appear as maggots which at first are less than 2 mm. (one-twelfth of an inch) long. When fully developed in the sheep, they are usually over 2 cm. (four-fifths of an inch) long and 7 mm. (almost one-third of an inch) wide, though the grub may contract or expand to a smaller or greater dimension. There are 11 segments, rather flattened on the ventral (lower) surface and arched on the dorsal (upper) surface. The ventral surface is spiny, the dorsal smooth. At first the grubs are white, later they become yellowish and darker, a band appearing on the dorsal side of the segments and finally becoming black. (Fig. 11.) At the head end are two large hooks and at the tail end are two rounded breathing pores.

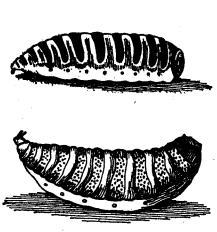

FIGURE 11.—Grub in the head (*Oestrus ovis*). Above, normal position: below, grub turned on its back. (From Osborn, after Riley)

Life history.—The adult fly (fig. 12), which looks something like an overgrown house fly, is active during the summer, usually in June and July. The female fly deposits a tiny grub on the edge of the sheep's nostril. Sheep usually run when the fly attacks them or is seen by them, often becoming frantic and holding the nose in the dust or against other sheep. The attack occurs usually during the heat of the day, the fly being quiet in the early morning and late afternoon. The grub migrates up the nostrils by means of its hooks and spines, and may make its way to the communicating cavities. Occasionally grubs fail to leave the sinuses in time and become too large to get through the apertures they entered; these die and usually become calcified. The grub in the sinuses feeds and grows until it is ready to leave the sheep. The length of time required for the grubs to reach maturity in the head of the sheep may vary from 1 to 10 months. At maturity they leave the sheep and fall to the ground, into which they burrow a short distance. Their skin becomes hard and leathery, and they lie quiescent for three weeks or two months, according to conditions of temperature and moisture. Finally the adult flies break out from the leathery envelopes within which they have undergone their transformation from the preceding stage, like a butterfly in a

chrysalis, crawl to the surface, and are ready to mate and then to deposit their young.

Distribution.—This parasite appears to be prevalent throughout the United States wherever sheep are kept.

Symptoms and lesions.—As the grub crawls about in the nostrils the hooks and spines set up an irritation which is at first acute, causing a profuse discharge from the nose, resembling a "cold in the head." Presently the nostrils show evidence of bacterial infection, the flow thickens and becomes discolored, presenting the condition called "snotty nose" by sheepmen, a pronounced catarrhal condition. The hooks and spines set up minute hemorrhages, which are visible on post-mortem examination as rows of blackened dots on the mucous lining of the nostrils and sinuses. One result of this irritation and inflammation is a thickening of the mucous membrane, a condition which interferes with the normal function of smell and helps to close the breathing passages, which are already functioning improperly as a result of the thick, catarrhal secretions. Consequently the sheep experiences difficulty in breathing, and this tends to impair its general physical condition. Add to this the fact that the sinuses may become filled with purulent matter and that the toxins from the purulent matter are constantly absorbed and there is evidently present a condition which must weaken an animal. Furthermore, the irritation due to the wandering of these spiny grubs over the sensitive mucous membrane of the nostrils prevents the sheep from resting or devoting its full time and energy to feeding and growing.

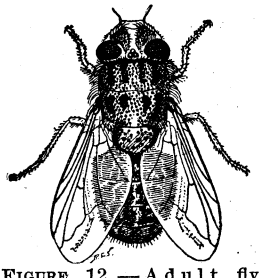

FIGURE 12.—Adult fly which causes grub in the head (*Oestrus ovis*). Enlarged. (From Bau)

Though the characteristic symptom of grub in the head is the profuse discharge from the nose, the sheep show other evidences of the infection. They sneeze frequently and often show symptoms of difficult breathing. The eyes become inflamed, as would be expected in connection with an inflammation of the nostrils, the head is often carried low or may be moved about in a peculiar manner as though the sheep were trying to rid themselves of an obstruction in the head, the appetite is diminished, or at least the sheep eat less owing to distraction from pain and difficult breathing, and in severe cases the animals may have convulsions and ultimately die.

Treatment.—An effective treatment for this condition has been developed in the Bureau of Animal Industry. It consists in a thorough and careful irrigation of the nasal passages of infested sheep with a 3-percent solution of saponated cresol. Approximately 1 fluid ounce of the solution is injected into each nostril under a pressure of from 35 to 45 pounds from a suitable pressure tank. The best time to give this treatment is in the fall or early winter, as soon as possible after the botflies have been destroyed by freezing temperatures. Treatment at this time should aid in controlling head grubs in areas where the winters are cold. Other treatments are reported to be of some value but all require considerable skill and care in administering. Another

treatment is to put the sheep in an enclosure on hard ground or on a floor which has been sprinkled with lime, and to mill them around so as to stir up the lime and cause violent sneezing, in the hope of expelling the grubs. This may remove some grubs from the nostrils but not from the sinuses. It has been reported that the introduction into each nostril of 3 c.c. of a mixture of equal parts of carbon disulphide and a light mineral oil is of value in killing the grubs. In valuable animals which are seriously affected, the sinuses may be opened with a trephine and the grubs extracted with forceps. This operation should be done by a competent veterinarian.

Prevention.—So far no means of preventing infestation have been discovered. Critical experiments indicate that smearing the noses of sheep with pine tar or other sticky substances is ineffective as a preventive. Mechanical devices, such as nose guards intended to keep the flies from attacking, have also failed to provide protection.

TAPEWORMS

Adult tapeworms are usually composed of a head, armed with hooks and suckers, as a rule (though those in the sheep's intestines have no hooks), and a body consisting of a number of flat segments arranged in a chain. Adult tapeworms are usually found in the small intestines, but in some cases they may occur in the stomach, large intestines, or the ducts of the liver and pancreas. Tapeworms produce eggs of microscopic size which pass out in the feces and on being swallowed by a suitable host, usually of a sort different from the host of the adult tapeworm, give rise to an intermediate stage, or larva, which is usually more or less spherical or elliptical and composed of a tapeworm head and neck attached to a membrane, the membrane usually inclosing a clear fluid. In the case of many of the common tapeworms this form is called a bladderworm. It usually occurs in the body tissues, and when it is eaten by the host of the adult tapeworm the head of the tapeworm passes to the intestine and forms the adult worm by the addition of segments back of the head. This tapeworm in turn produces eggs and the cycle is repeated. Thus, certain tapeworms in the dog give rise to certain bladderworms in sheep, the tapeworm eggs in the feces of the dog being deposited on the pasture and picked up by sheep with the herbage that they eat. The dog in turn becomes infested with tapeworms when it eats the bladderworms in the meat, brain, liver, entrails, or other parts of the sheep.

Sheep may harbor adult tapeworms in the intestines and bladder worms in the body tissues.

THE MONIEZIAS

Location.—These tapeworms (*Moniezia expansa* and *M. benedeni*) are found in the small intestines.

Appearance.—They are whitish to yellowish in color and may attain a length, in some specimens, of several yards. (Fig. 13.) The individual segments of a worm are broader than long, and each segment contains at some period of its development a complete set of reproductive organs. The end segments are full of eggs, and these segments break off from the rest of the worms and pass out in the manure, where they are often found by the farmer and regarded as complete worms. The presence of these segments in the feces serves to diagnose cases of infestation with the tapeworm.

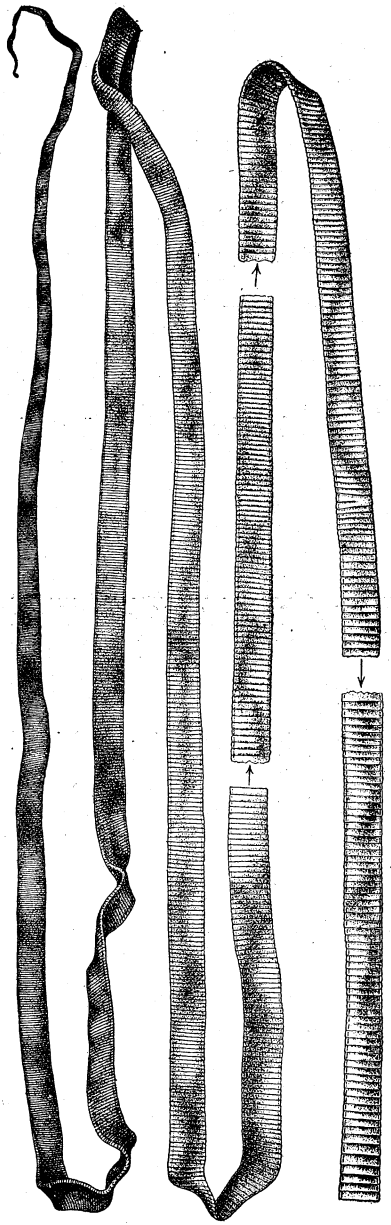

FIGURE 13.—Tapeworm (*Moniezia expansa*). About natural size. (From Stiles)

Life history.—The life history of these tapeworms remained quite unknown until recently, when it was ascertained that certain free-living mites may serve as intermediate hosts. These free-living mites are found on blades of grass in the infested pastures and as the sheep graze they pick up the mites and become infected.

Distribution.—These tapeworms are more or less common throughout the United States. These two forms (*M. expansa* and *M. benedeni*) are also widely distributed outside the United States.

Symptoms and lesions.—When these worms are present in sheep in large numbers they cause obstruction of the intestine and intestinal irritation, with the result that they interfere with digestion, and the sheep become unthrifty, weak, and emaciated; such sheep are unable to stand adverse conditions, such as bad weather or poor feed, and die when sheep not so infested may survive. The digestive derangement is manifested by diarrhea as a rule. It is known that tapeworms often cause very marked and even severe nervous symptoms in man, and while such symptoms are more difficult to detect in sheep there is every reason to suppose that they may occur.

On post-mortem examination of affected sheep the tapeworms are found in the small intestine, often in large numbers. The sheep

show no special indications of their presence other than poor condition, evidences of diarrhea, and inflammation or catarrh of the intestines.

Treatment.—Various treatments have been recommended. Among the remedies which have been used are the following:

Kamala.—This drug has been given in doses of 1 dram to lambs. It causes diarrhea, and lambs so treated may remain poor for some time in spite of abundant feed and good conditions otherwise.

Kamala and copper sulphate.—A mixture of kamala and finely powdered copper sulphate has been recommended for the removal of these tapeworms from sheep. The mixture is prepared by adding 3 ounces of finely powdered copper sulphate to 1 pound of kamala, and is administered in hard gelatin capsules in the following dosage: Adult sheep, 1.5 drams; 60- to 90-pound lambs, 1 dram; 40- to 60-pound lambs, 40 grains; 30- to 40-pound lambs, 30 grains.

Oleoresin of male fern.—This is given in doses of 1 dram, and may be given with 2 to 4 ounces of castor oil.

In South Africa good results have been reported from the use of a mixture containing 1 part of sodium arsenite (testing 80 per cent arsenious oxide) and 4 parts of copper sulphate. The total dose of the mixture is as follows: For animals 2 to 4 months old, 180 milligrams; 4 to 6 months old, 250 milligrams; 6 to 10 months old, 375 milligrams; 1 year old, 500 milligrams; 2 years old or older, 625 milligrams. This may be given as a powder. Withhold feed and water the afternoon before dosing; dose the following morning; allow feed that afternoon and feed and water the next morning. The dose may be repeated the day after the first dose, in which case feed is allowed the afternoon after the first dose, the animal is dosed the following morning and fed that afternoon, but no water is allowed from the afternoon preceding the first treatment until the morning following the second treatment. Owing to the poisonous nature of arsenic, it is best to test the treatment on a few sheep to be sure the dose is safe before dosing a flock, and the drugs should be kept out of reach of children and animals. If the treatment is repeated at intervals of a month or more through warm weather, the single treatment should be used.

The Oklahoma experiment station reported very good results from a solution containing 1 per cent copper sulphate and 1 per cent by weight of snuff or powdered tobacco. The tobacco is steeped overnight and the copper sulphate then added. The dose is 50 c. c. (about 1½ ounces) for lambs and twice this amount for full-grown sheep.

A 40 per cent solution of nicotine sulphate has replaced to a large extent the snuff or powdered tobacco for making a copper sulphate solution containing nicotine. One ounce of the nicotine-sulphate solution should be added to each gallon of copper-sulphate solution as recommended on page 32 in connection with treatment for the removal of stomach worms. *It is not advisable under any circumstances to increase the quantity of nicotine sulphate added to each gallon of copper-sulphate solution.* If a precipitate forms, the mixture should be stirred regularly to prevent sedimentation of the nicotine-sulphate–copper-sulphate colloids. The dose of the combined solution is the same as for the snuff or powdered-tobacco solution, but should be diminished if

the full dose produces unpleasant symptoms. It should not be given to very old or very young animals, to animals in a weakened condition, or to those suffering from disease conditions other than of parasitic origin. The alternating use of this solution with the straight copper-sulphate solution is often good practice. Sheep frequently show symptoms of distress after the first few dosings with the copper sulphate and nicotine sulphate solution, but tolerate it better later.

In some cases use of the above-mentioned treatments will remove only the segments of the tapeworms and will not remove the heads. For this reason it may be necessary to repeat the treatment at 3- to 4-week intervals.

Prevention.—No dependable preventive measures against these tapeworms can be recommended.

FIGURE 14.—Fringed tapeworm (*Thysanosoma actinioides*). About natural size. (From Stiles)

THE FRINGED TAPEWORM

Location.—This tapeworm (*Thysanosoma actinioides*) is found in the small intestine, the gall ducts, gall bladder, and biliary canals of the liver, and in the duct of the pancreas.

Appearance.—These are whitish or yellowish tapeworms and may be a foot long (fig. 14), but are commonly shorter. They may readily be distinguished from other tapeworms by the fact that each of the segments has a fringe on its posterior border. This fringe may be most easily seen when the segment is put into water, where the fringes can float out from the segment. Tapeworms found in the liver or pancreas will be this worm, not the Moniezias already described.

Life history.—The life history of the fringed tapeworm has not been worked out. It may be similar to that of the Moniezias but no definite statement concerning this matter can be made.

Distribution.—The fringed tapeworm is a parasite of western sheep and is found in the East probably only when the sheep have been shipped from the West. The infected range probably is confined to North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, and the States west of them. The parasite apparently has found conditions most favorable among range sheep, and it seems to be losing ground with the breaking up of the big western sheep ranges and the substitution of small holdings of sheep.

Symptoms and lesions.—The obstruction of the bile ducts and pancreatic ducts causes inflammation of these ducts and derangement of the liver. As a result there is an alteration in the quantity

and character of the secretions, which impairs digestion and causes a lack of thriftiness. This shows in lost flesh and poor quality of flesh and wool. Sheep weakened by fringed tapeworms may die from the parasitic infestation or from inability to withstand other adverse conditions. Infested sheep are commonly hidebound and suffer from diarrhea.

On post-mortem examination the tapeworms may be found in the intestine and in the liver and pancreas, and the ducts of these glands are usually found thickened when infested. In the spring of the year fringed tapeworms seem more likely to be found in the small intestines than at other seasons.

Treatment.—No successful treatment is known for this parasite. Such treatments as have been attempted have failed, and all that can be recommended at this time are careful nursing and good feeding.

Prevention.—As in the case of the Moniezias, it is impossible to give specific directions for preventing infestation.

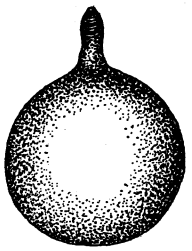

FIGURE 15.—Thin-necked bladderworm (*Cysticercus tenuicollis*). Natural size. (From Stiles)

BLADDERWORMS

THE THIN-NECKED BLADDERWORM

Location.—The thin-necked bladderworm (*Cysticercus tenuicollis*) is found in the abdominal cavity attached to the mesenteries or omenta or in the liver.

Appearance.—The bladderworm looks like a sac full of a clear fluid with a white object which is the head and neck, projecting into it from one end. It is usually about 1 inch in diameter, but may attain a long diameter of several inches. The bladderworm proper is surrounded by a cyst, which is developed by the host animal as a protective measure against the parasite. When this cyst is broken the parasite usually rolls out and is seen to be a thin-walled structure. By careful manipulation the head and its rather long neck may be squeezed out at one end of the "bladder." (Fig. 15.)

Life history.—If one of these bladderworms is fed to a dog, the cyst wall will digest, but the tapeworm head and neck will pass on to the small intestine of the dog and begin to grow segments back of the neck. In this way it will form a tapeworm, one of the largest of the dog tapeworms (commonly called *Taenia marginata*, and more properly *Taenia hydatigena*). (Fig. 16.) This tapeworm attains a length of a yard or more, becoming mature and beginning to liberate egg-bearing segments in the course of 10 or 12 weeks. When dogs infested with these tapeworms run over pastures used by sheep they leave feces containing tapeworm eggs on the pasture, and these eggs are spread by rain and washed onto the grass and into streams and puddles, where the sheep drink. When the sheep get these eggs in food or water the embryo escapes from its surrounding shell, makes its way to the liver of the sheep, and begins to develop. In time it slips out of the liver and becomes attached to the mesenteries or omenta. At first it is a bladder without a head, but later the head and neck develop, and it is then ready to infect any dog that eats it.

Distribution.—This parasite is quite generally distributed over the United States, but the indications are that the worm is becoming less common as a result of improvements in disposal of viscera and offal at slaughterhouses during the last 20 years. It is most likely to be present where sheep are associated with dogs, either when herded by them or where stray dogs are common, and where sheep are slaughtered on farms or at small country slaughterhouses at which little care is exercised in disposing of the viscera and of diseased portions of carcasses.

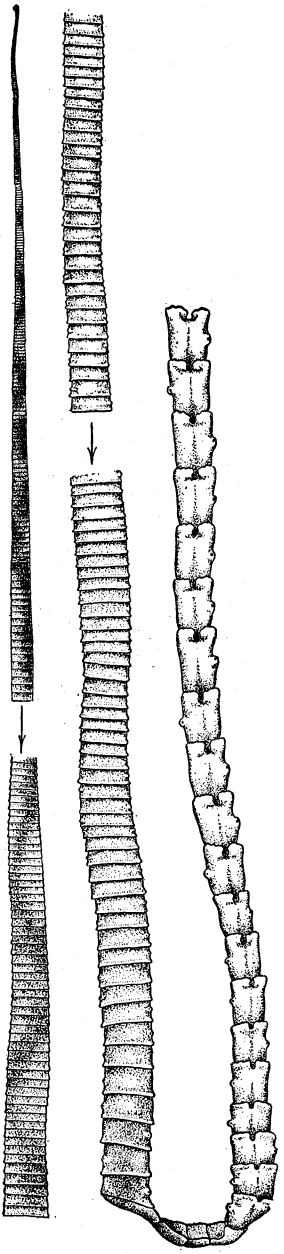

FIGURE 16.—Tapeworm (*Taenia hydatigena*) of dog, developed from thin-necked bladderworm of sheep. About natural size. (From Stiles)

Symptoms and lesions.—Light infestations with these bladderworms seem to do very little damage. Severe infestations, such as a sheep would get by eating grass that had an entire segment full of eggs on it, will make a sheep very sick and may kill it. Under these conditions sheep usually die at a rather early stage of the disease, while the embryos are wandering around in the liver, the immediate cause of death being hemorrhage from the liver, or peritonitis. Post-mortem examination under these conditions would seldom be sufficiently minute to reveal the exact cause of the trouble, and it would seldom be charged to this parasite.

On post-mortem examination the bladderworms are usually readily observed in the mesenteries or omenta, or, in earlier stages, in the liver. When the liver has just recently been invaded, the presence of the parasite is usually indicated by serpentine markings showing the course of the wanderings of the young worms.

Treatment.—There is no treatment for infestation with the bladderworm in sheep.

Dogs should be kept free from tapeworms of any sort, including the one responsible for this bladderworm in sheep. For removing these tapeworms fast the dog from noon of one day until the following morning and then give it one of the following treatments:

Oleoresin of male fern.—The dose for dogs is 15 minims to 1 dram (a quarter of a teaspoonful to a teaspoonful), according to size. This may be given in capsules and followed immediately by an ounce of castor oil.

Areca nut.—This may be given in the same amounts as the oleoresin of male fern, and will usually not need a purgative, as areca itself is a purgative. If feces are not passed in the course of four or five hours, it is advisable to give castor oil or some other purgative. As noted previously, areca nut must be freshly ground to be efficacious.

Arecoline hydrobromide.—For large dogs, one-half grain; for dogs of moderate size, one-fourth grain; for small dogs, one-eighth grain. No purgative should be given, as this drug is itself purgative.

Kamala.—This may be given in doses of half a dram to 2 drams (a half teaspoonful to 2 teaspoonfuls). The powder may be given in sirup and will not need to be followed by a purgative, as kamala itself is a purgative. As in the case of areca nut, if feces are not passed in four or five hours, castor oil or some other purgative should be given.

Any tapeworms that are passed and the feces with them should be burned. On the farm this is easily done by using hay or straw for fuel.

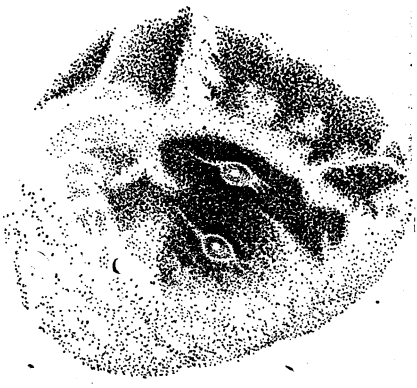

FIGURE 17.—Sheep muscle showing measles (*Cysticercus ovis*). Natural size. (From Ransom)

Prevention.—This consists in preventing dogs from eating uncooked meat, especially diseased and parasitized meat and viscera. Slaughterhouse refuse should be tanked and not left where dogs can have access to it. The use of the tank has apparently resulted in a diminution in the number of cases of this parasite in sheep and dogs, and the extension of this measure will probably eradicate it in time. Dogs should be kept free from tapeworms by suitable remedies, whenever necessary, and it would be advisable to give such treatment as a routine procedure about four times a year where there is any chance of dogs eating infective material. Stray dogs should be kept off farms and suppressed by appropriate measures.

SHEEP MEASLES

Location.—Parasites known as sheep measles (*Cysticercus ovis*) occur in muscles, including the heart, and intermuscular connective tissue, and as degenerate cysts in the lungs, walls of the first and fourth stomachs, and the kidneys.

Appearance.—This parasite occurs in the meat (measly mutton) as oval cysts 3.5 to 9 mm. (one-seventh to one-third of an inch) long by 2 to 4 mm. (one-twelfth to one-sixth of an inch) wide. These cysts have a thin external membrane inclosing a clear fluid. On one side of the cyst is an opaque white object, which is the head and neck of a tapeworm. (Fig. 17.) When degenerated the cysts appear as cheesy or hard nodules, the hardness being due to lime salts.

Life history.—The life history of this parasite is similar to that of the thin-necked bladderworm, the adult being a certain species of tapeworm of the dog (*Taenia ovis*).

Distribution.—In the United States this parasite appears to be most common in the West, especially in Montana, Idaho, Washington, Oregon, California, Colorado, and Nevada. It has been found abroad in England, France, Germany, Algeria, Southwest Africa, New Zealand, and South America.

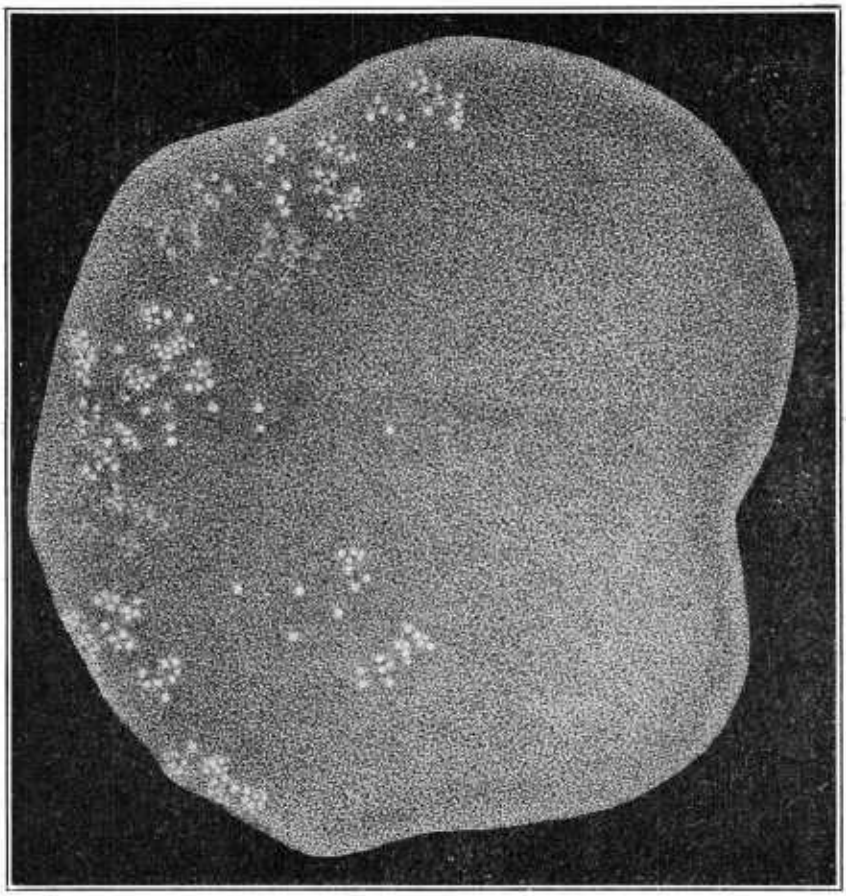

FIGURE 18.—Gid parasite (*Multiceps multiceps*) from brain of sheep. Natural size. (From Hall)

Symptoms and lesions.—When sheep have but a few of these cysts no symptoms are likely to be observed. When many cysts are present sheep will become very sick, and if all the eggs from one segment are eaten by a sheep it is likely to die. On post-mortem examination the cysts are the principal thing observed, though in badly infested cases the meat may be watery and discolored.

Treatment and prevention.—These are the same as for the thin-necked bladderworm (p. 20) and its adult tapeworm.

THE GID PARASITE

Location.—The gid parasite (*Multiceps multiceps*. Synonym, *Coenurus cerebralis*) occurs in the brain or spinal cord. Degenerate worms that failed to reach the central nervous system may be found in muscles and other tissues.

Appearance.—This worm occurs as a large cyst or bladderworm, attaining the size of a hen's egg or larger, and is composed of a thin membrane containing a rather large amount of fluid. On the bladder membrane are a number of small, white objects about the size of a grain of wheat, projecting, as a rule, into the bladder fluid. (Fig. 18.) These are the tapeworm heads. A parasite of this sort is called a coenurus.

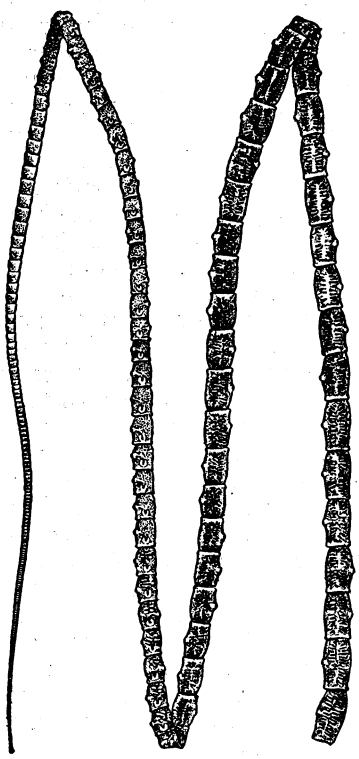

FIGURE 19.—Tapeworm stage of *Multiceps multiceps* in the dog. Actual size. (From Hall)

Life history.—When such a bladderworm, or coenurus, is eaten by a dog, fox, or coyote the bladder membrane digests, releasing the attached tapeworm heads. These heads then pass into the small intestine, where they form the adult tapeworms by the addition of segments back of each head. (Fig. 19.) Ordinarily the worm is fully grown and 2 or 3 feet long in the course of a month or two, though occasionally a longer period is required. The full-grown tapeworm produces minute eggs, which pass out in the feces of the dog on to the pasture or range. Under favorable conditions these eggs are taken in by sheep with contaminated feed or water. The shell digests from the egg and releases an embryo, which is armed with six hooks. By means of these hooks the embryo cuts its way through the tissues of the sheep and into the blood stream. In the blood the embryos are carried to various tissues, but only those that reach the brain or spinal cord are able to attain the full larval development, the others dying and degenerating by the time they reach the size of a pea. Those that reach the central nervous system at first move about on or in the brain or spinal cord, forming curving channels. At a suitable point the wandering ceases and the bladderworm grows and completes its development in about seven or eight months, the sheep dying in nine months or earlier.

Distribution.—In the United States this parasite has been found chiefly in northern Montana, where it has been established since about 1890, possibly longer. There have also been outbreaks of gid in Arizona and in New York. Cases have been observed also in various localities to which sheep have been shipped from infested

regions. Occasionally cases are imported from Europe. Outside the United States the disease is known to occur in England, Scotland, Ireland, France, Germany, Austria, Hungary, Italy, Sardinia, Switzerland, Greece, Spain, Holland, Denmark, Iceland, Shetland, Morocco, Cape Colony, Southwest Africa, South Australia, New Zealand, Argentina, Chile, Canada, and Mexico.

Symptoms and lesions.—At the time that the young worm gets to the brain there are usually slight symptoms of fever and restlessness, which are easily overlooked. If the sheep dies at this time, as a result of severe infestation, an examination of the brain will show a number of curving channels on its surface. As a rule the symptoms of this stage abate and there is no further indication of the presence of the parasite until it has grown to the point where the heads form. This will take place about the seventh or eighth month after infection. The head of the worm can be evaginated from the bottom of its tubular neck, just as a glove finger may be turned inside out, and this brings its hooks and suckers into contact with the brain. From this irritation and from the pressure of the growing bladderworm there arise the very striking symptoms indicative of gid. Affected sheep very commonly walk in a circle, turning toward the side corresponding to the affected portion of the brain when the parasite is on the surface of the cerebrum. When the parasite is located at another point the symptoms are somewhat different. In these cases sheep may walk with the head held high and may step high, or with the head held low and with a stumbling gait, or may show other odd symptoms in the way of unusual locomotion. Such animals gradually lose interest in feed and water and finally cease eating or drinking. In consequence they become very much emaciated. They may move about continuously or stop at times and gaze fixedly at nothing in particular. They are difficult or impossible to herd and tend to lag behind the flock or become lost. The head is often carried to one side and the animal may become blind or appear to be blind.

Unless surgical treatment or accident frees the sheep from its parasite, the animal will die, usually in the ninth month. When examined after death the brain or spinal cord will be found to have on or in it a bladderworm, or more than one, and an equal amount of brain or cord tissue will have disappeared or been crowded aside by the growth of the cyst. The skull adjacent to the parasite is often softened or even absorbed to the point where it has a hole or several holes through it. In the late stages sheep are so emaciated that the meat is unfit for food.

Treatment.—The treatment for gid is surgical. This is satisfactory only when the cyst is on the surface of the brain. Operation may be performed with a trocar and cannula or with a trephine. In the trocar and cannula operation the wool is sheared over the affected area, as determined by the symptoms and by palpation to find a soft spot or one where the sheep reacts violently to pressure. Under local anesthesia the trocar and cannula are driven through the skull and the trocar withdrawn from the cannula. If the cyst is struck, a watery fluid will issue from the cannula. This fluid is syringed out and the cannula withdrawn. Suitable cannulas are provided with a cleft to catch the bladder membrane and pull it out. If this fails, it is necessary to remove the membrane with forceps or by some other

means. This operation, like operations generally, should be conducted under aseptic conditions. The median line of the skull should be avoided.

With the trephine outfit the wool is sheared over the proper area and under local anesthesia and aseptic conditions a V-shaped incision is made through the skin and the skin dissected back. A piece of skull is then cut out with a 5/8-inch trephine and the hard membrane covering the brain is cut with bent scissors. The parasite will usually push out and may be grasped with forceps and removed. If it does not appear, it may be necessary to explore for it with the finger. After removing the parasite and controlling the hemorrhage, the skin flap may be sewed back along one side of the tip of the V, and the wound covered with a pledget soaked in some antiseptic. The animal should be kept quiet in a dark shed for several days after operation.

Some sheepmen cut the skull with a pocket knife or puncture the cyst with a knife. In such cases the sheep is apt to die of infection, even if the worm is removed. The operation for gid calls for care and should be performed by a competent veterinarian. If an operation does not seem to be feasible, it is advisable to kill giddy sheep for mutton or send them to market before they become emaciated and unfit for food.

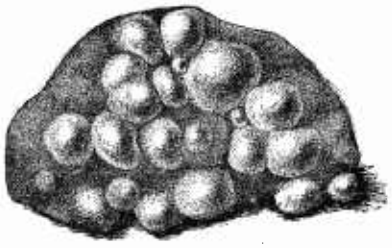

FIGURE 20.—Hog liver infested with hydatid (*Echinococcus granulosus*). Greatly reduced. (From Stiles)

Prevention.—The most important preventive measure is to destroy the heads or at least the brains of giddy sheep. This may be done by burning. Where wood is scarce the skull may be split with an ax or a cleaver and the brain put on a forkful of hay or straw and burned. Where this is not feasible the brain may be removed from the skull, crushed, and covered with formaldehyde, turpentine, or a coal-tar or tobacco dip. The essential thing is to destroy the parasite to prevent dogs, coyotes, or other animals from eating it.

Another measure of importance is to keep dogs, especially sheep dogs, free from tapeworms. To this end it is advisable that they be given tapeworm treatment four times a year. For the treatments that may be used see page 20. Measures against coyotes and other noxious wild animals are valuable in controlling gid as well as in keeping down the destruction of stock. Stray dogs should be eliminated on the same grounds.

THE HYDATID

Location.—The preferred sites of the hydatid parasite (*Echinococcus granulosus*) in sheep are the liver and lungs, but it may occur in practically any organ or tissue.

Appearance.—The parasite occurs in sheep usually as a multiple bladder worm, varying from the size of a nut to the size of a child's head, sometimes as a spherical object and sometimes irregular in shape. (Fig. 20.) It has a very thick, laminated bladder wall,

and in the simplest form of the parasite this bladder contains a clear fluid and minute objects resembling grains of sand lying unattached in the fluid. These grains are brood capsules, and each of them contains a number of very small tapeworm heads. Sometimes the bladder worm develops other bladder worms, attached or unattached, on the inside or outside.

Life history.—When the brood capsules from a hydatid are eaten by a dog, cat, or other suitable animal, each tapeworm head in the brood capsules develops into a tapeworm by the addition of segments back of the head. This tapeworm is a very small one, less than half a centimeter (about one-fifth of an inch) long. (Fig. 21.) As the hydatid may form thousands of such heads in its brood capsules, dogs may, on eating hydatids, become infected with large numbers of these worms. The eggs produced by the adult tapeworms in the dog pass out in the feces. When taken in by a sheep or other animal the egg hatches and releases an embryo which makes its way to some suitable tissue and develops into the hydatid. This hydatid may develop in man if an egg of the tapeworm is swallowed, and a large percentage of hydatid infestations in man result in death. It is therefore a very dangerous parasite to human beings.

FIGURE 21.—Hydatid tapeworm (*Echinococcus granulosus*). Highly magnified. (From Stiles, after Leuckart)

Distribution.—This parasite has been found at a number of places in the United States proper and in Alaska, as well as in other parts of the world. Certain regions are found to send a large number of infected swine to the slaughterhouses, though its occurrence in sheep is comparatively rare in the United States, contrary to observations in other parts of the world where sheep are more commonly infested than are swine. Where it is locally prevalent, its abundance may be attributed to infected dogs which probably have become infected through carelessness in the disposal of diseased carcasses and viscera of slaughtered animals. Careless persons may feed diseased portions of carcasses to dogs or leave them where dogs get at them and eat them.

Symptoms and lesions.—The symptoms in sheep affected with hydatid depend on the location of the parasite and its size, and so are extremely variable. Where the parasite is small or has room to develop without crowding important organs, few symptoms may be noticed. On the other hand, the parasite may develop in such structures as the brain or heart and cause very marked symptoms and sudden death from pressure or rupture. As a rule, infestations will not be detected and correctly diagnosed during the life of a sheep, but will be found only on post-mortem examination. In such cases the large, thick-walled bladders are readily found.

Treatment.—The only treatment for this condition is surgical, and this is not apt to be feasible in sheep, even if the disease should be diagnosed ante mortem.

Prevention.—The most important measure in the way of prevention of this disease is the proper disposal of carcasses and portions of carcasses of animals dying on the farm or killed there or else-

where. The "condemned" tank at the modern slaughterhouse has been one of the greatest factors in destroying parasites of this sort, and the lack of an equally good arrangement at the small country slaughterhouse and on the farm is one of the important conditions which permit such parasites to persist. Where diseased viscera, such as livers infested with hydatids, are thrown out where dogs can get at them, parasites of this kind are likely to be prevalent. The next measure of importance in controlling this disease is to keep dogs free from tapeworm by administration of tapeworm treatments four times a year. For these treatments, see page 20. Owing to the danger of persons acquiring hydatid disease and the serious nature of this disease in man, dogs known to harbor this tapeworm should be killed and burned or buried deep in quicklime.

FLUKES

Flukes are usually flat, leaflike animals, provided with suckers, but not segmented like the tapeworms. They occur in the adult stage in various locations, the stomach, intestines, liver, lungs, and blood vessels, and may occur in immature stages in such tissues as the muscles. The adult flukes produce eggs of microscopic size, which pass out and hatch in water. The embryos released from the eggs infect snails, in which they transform into a succession of larval stages. The parasites finally escape from the snails, and may penetrate the skin of the final host or may be swallowed, sometimes after encysting, in food or water.

FIGURE 22.—Common liver fluke. (*Fasciola hepatica.*) Natural size. (From Stiles)

Sheep in certain localities in the United States, as well as in other parts of the world, suffer considerably from fluke infestation. The common liver fluke and the large liver fluke occur in American sheep.

THE COMMON LIVER FLUKE

Location.—These flukes (*Fasciola hepatica*) are found usually in the biliary canals and the ducts of the liver, though they may occur as wandering parasites in the lungs and elsewhere.

Appearance.—The common liver fluke is a flattened, leaflike, brown animal, usually about an inch long. (Fig. 22.) There is a sucker at the anterior, or front end, on a cone-shaped extension, and just behind this is a ventral sucker. Through the skin or cuticula covering the animal one can see the branching intestine and the uterus filled with eggs.

Life history.—The eggs produced by the adult flukes pass out in the feces and on getting to water release a ciliated embryo. This embryo attacks certain species of snails (*Galba bulimoides*, *G. b. techella*, and *G. ferruginea*) and on entering the snail undergoes certain changes, which in time give rise to a form called a cercaria. This is like a small fluke provided with a tail by means of which it swims about. Finally it loses the tail and encysts. The encysted cercariae may float about on or in water or may be attached to grass

blades or other vegetation. When these are swallowed by sheep, or other suitable host animals, the larval flukes escape in the digestive tract and bore their way through the intestinal walls to the body cavity. Here they wander over the surface of the viscera and the walls of the body cavity and as a rule finally perforate the capsule of the liver and reach the extremities of the biliary canals. A few go astray and perforate the diaphragm, getting into the lungs. In the liver the younger flukes grow and make their way down the canals, the larger ones being found in the bile ducts, and begin again the life cycle with the formation and passage of eggs. The flukes may get to the liver by way of the blood stream.

Distribution.—This parasite occurs over a large part of the world, where low, wet pastures and the presence of suitable snails make it possible for it to exist. It occurs in about 20 States in this country, and is most prevalent in Washington, Oregon, California, Utah, Texas, Arkansas, Louisiana, and Florida. It is also prevalent in Puerto Rico and Guam.

Symptoms and lesions.—Sheep are likely to put on fat and seemingly improve in condition in the early stages of liver-fluke disease, usually in the summer and fall, apparently as a result of a stimulation of the functions of the liver. Later, however, they lose in condition. The skin and mucous membranes are paler and the animal is less lively. It feeds less and ruminates less. Edema appears as the composition of the blood is altered, and may be seen as swellings along the pendant portions of the body; for example, in the region under the jaw. Dropsy is often present. During the winter the sheep becomes leaner, breathes rapidly and feebly, and is dejected. A diarrhea is usually present at a late stage of the disease.

The animal may die at any stage of the disease, but if it survives the attack the flukes eventually leave the sheep and a part of the damage is repaired. Total recovery is hardly possible, as the liver is burdened with scar tissue in the areas where the flukes have been. The disease may be diagnosed from its symptoms, if one is familiar with it, but a safer diagnosis is based on the finding of the worm eggs in the sheep manure.

For the purposes of the farmer and sheepman the surest diagnosis is made by killing a sick sheep and making a careful post-mortem examination. If the ducts of the liver are carefully slit and examined, the flukes will be found as dark, leaflike objects which if watched a short time will show movement. The liver may be washed in a plentiful supply of clear water as it is cut up, and the water examined for the flukes that may wash out. The liver of infected sheep is softened and roughened, and may show channels under its capsule. In old cases puckered scar areas are present. The softening of the liver gives the name of "liver rot" to the disease. The biliary canals and gall ducts are much thickened and enlarged and often are marked by ridges on the surface of the liver.

Treatment.—The remedies which have been found most satisfactory are male fern and carbon tetrachloride. The latter is much the cheaper and is preferable for treating sheep.

Oleoresin of male fern is administered as follows: Give by mouth 3 to 5 grams of the male fern (from ¾ of a teaspoonful to 1¼ teaspoonfuls), according to the size of the sheep, in 10 c. c. (2½ tea-

spoonfuls) of a nonpurgative oil, in the morning, two hours before feeding. Administer the treatment on two to five consecutive mornings. The male fern should contain 24 to 25 per cent of filicine and 3.5 per cent of filicic acid.

It has been found by European workers that 1 c. c. of carbon tetrachloride administered in capsule to a sheep will kill all the liver flukes present with the exception of the very small ones. This treatment has the advantage of being very cheap, simple, and safe, and does not have any bad effect on the sheep in the vast majority of cases. Apparently one dose is sufficient, and the animals can be dosed effectively in the morning without special attention to fasting. The treatment has been used very successfully in this country. See comment on this drug under "The Nodular Worm," page 39.

It is advisable to have these drugs administered by a competent veterinarian.

Prevention.—The manure from infected sheep in sheds or inclosures should not be put on pasture, especially on wet ground. Sheep should be kept off wet pasture in places where fluke is prevalent, and swampy areas should be drained, filled, or fenced off. Frogs, toads, and carp are useful in the control of snails. Safe drinking supplies must be provided for sheep as the infection may be water borne.

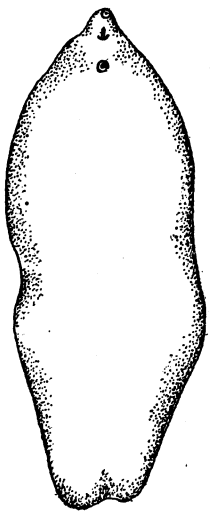

FIGURE 23.—Large liver fluke (*Fascioloides magna*). Natural size. (From Stiles)

It has been found in Europe and in the United States that a 1 per cent solution of copper sulphate applied to infested pastures, especially to wet areas, such as marshes and low swales, is very effective in destroying snails and preventing losses from flukes. On large, wet areas a mixture of 1 part powdered copper sulphate by weight to from 4 to 8 parts of fine, dry sand may be applied by broadcasting, and this may also be done along the margins of ditches or streams. Snails in small streams may be destroyed by putting a gunny sack containing a few pounds of large crystals of copper sulphate in the headwaters. Damming the stream at intervals aids in destroying snails along the banks.

THE LARGE LIVER FLUKE

Location.—The large liver fluke (*Fascioloides magna.* Synonym, *Fasciola magna*) occurs in the liver, commonly lying in cysts which contain one to several flukes and a quantity of dark-colored fluid filled with débris. While these cysts may originate in a biliary canal, they extend into the tissue, and the fluke is habitually found as a parasite in the liver substance in cysts and not as a parasite of the canals and ducts. Wandering flukes may be found in the lungs or elsewhere.

Appearance.—This is a large, thick species, which may attain a length of 10 cm. (4 inches). (Fig. 23.) The anterior, or front,

sucker is not carried on a distinct cone, as in the case of the common liver fluke, but in its general appearance otherwise the fluke resembles an overgrown specimen of the common liver fluke.

Life history.—The life history of the large liver fluke is much the same as that of the common liver fluke, with snails (*Galba bulimoides techella*) of the same species as the one that carries the common liver fluke, as intermediate hosts. In Canada two other species of snails, *Stagnicola palustris nuttalliana* and *Fossaria parva*, have been found to serve as intermediate hosts of this fluke under natural conditions.

Distribution.—North America appears to be the home of this fluke, although it has been transplanted elsewhere. In the United States it is most prevalent near the Gulf of Mexico, especially in Arkansas and along the coast and river valleys of Texas. It also occurs along the west coast in both the United States and Canada and seems to have obtained a foothold at some inland points, as in part of Colorado, Montana, Wisconsin, and New York.

Symptoms and lesions.—This parasite is much more common in cattle than in sheep. It seems to do rather little damage in cattle apart from rendering the livers unfit for use as food. In sheep, however, it may do considerable damage. Infected sheep lose condition, but the appetite persists up to the time of death. Edema is present in the form of watery swellings of the dependent portions of the body. Abortions have been reported as prevalent in a flock of infested sheep, though it is unsafe to associate this with the fluke without further evidence.

On post-mortem examination the livers show the characteristic cysts or else dark-bluish scars where the flukes have been and where healing has taken place. The flukes apparently die in the liver. The cysts take on the character of abscesses and may be present in the lungs and spleen as well as in the liver. Affected livers and other organs contain more or less coal-black pigment characteristic of the presence of this parasite. The worms may set up peritonitis, and the omentum may show black markings.

Treatment.—No treatment is known for this disease, though the use of oleoresin of male fern or carbon tetrachloride is indicated, as for the common liver fluke.

Prevention.—The same measures that are used in the case of the common liver fluke (p. 29) are indicated here. The destruction of the snail host by draining or filling wet areas or by treating such areas with copper sulphate promises better control than medicinal treatment.

ROUNDWORMS

The parasitic roundworms or nematodes are elongated, cylindrical, unsegmented worms. Some of them may be properly characterized as threadlike or hairlike. The body wall is usually rather transparent, and when the worms are examined with a microscope the internal organs are readily seen, usually in the form of a number of tubes. The sexes are generally separate and the males are usually smaller than the females. In general the females produce large numbers of eggs, though sometimes the eggs hatch in the body of the female and some roundworms produce embryos without the previous formation of an egg with its yolk material and shell.

Most of the roundworms of sheep reach the animal, in which they develop to maturity, by being swallowed directly as eggs or young worms without passing through part of their development in some intermediate host, as the tapeworms do. In some cases the young worms that have hatched in the fields penetrate the skin of the host animal, entering the body in this way instead of by the mouth. Other worms have an intermediate host and undergo a certain development in this host before getting to the final host. The intermediate host harboring the larval worms may be eaten by the final host, thus infecting it through the digestive tract, or such intermediate hosts as mosquitoes may infect the final host by biting it, the larval worms then penetrating the wounded skin.

Even in the case of direct infection, when eggs or young worms are swallowed by the host animal, nematodes which develop to maturity in the intestine may not go directly there and develop immediately. They may pass through the walls of the digestive tract and get to the blood stream, leave the blood stream for the air passages of the lungs, crawl up the windpipe, and then pass down the esophagus or gullet, and thus again reach the intestine, where they continue their development to maturity.

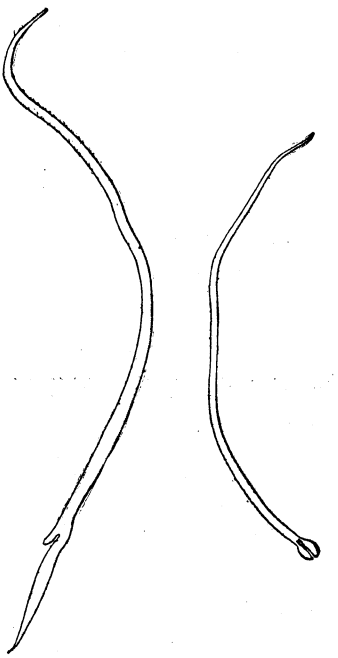

FIGURE 24.—Stomach worms (*Haemonchus contortus*). Right figure, male; left, female. Magnified five times

THE STOMACH WORM

Location.—This worm (*Haemonchus contortus*) is a parasite of the fourth stomach. It may be found elsewhere in the digestive tract, but such occurrences are of little significance.

Appearance.—Stomach worms (fig. 24) are from one-half to 1¼ inches long and about as thick as an ordinary pin. The females are the larger and have a spiral striping. In the rear half of the body of the female there is a projecting portion, which may be seen on close examination. The smaller male may be distinguished by the fact that the posterior or tail end of the body is flattened and expanded.

Life history.—The eggs produced by the female worms pass out in the manure and hatch in a few hours under the most favorable conditions of warmth and moisture. Under less favorable conditions hatching may require a number of days or even weeks. The embryo which leaves the egg undergoes further development until it becomes an ensheathed, infective larva. In this condition it is inclosed in a double skin and is very resistant. Whereas drying and low temperatures may kill the egg or embryo previous to this stage, the ensheathed larva can withstand severe cold and long periods of dry-

ness. When the grass is wet with rain or dew, these larvae crawl up the blades. Here they are swallowed by sheep as they graze. In the stomach the worms become mature in the course of two to three weeks, but do not begin to produce eggs in large numbers until about a month after they are taken in by the sheep.

Distribution.—The stomach worm occurs over almost the entire world, wherever there are sheep, cattle, or other suitable host animals. In the United States it is most plentiful in the South, where it is favored by abundance of warmth and moisture, but it is quite common and a serious pest in the Middle West and in low, wet areas throughout the entire country. It is present in smaller numbers and does less damage in the high, dry, and cool areas of the Rocky Mountain States, but irrigation supplies favorable conditions even here.

Symptoms and lesions.—The first things noticed about infested sheep are dullness and lack of thrift. Diarrhea may be present. Later, the more characteristic features of stomach-worm disease become evident in the form of anemia and edema. The anemia is manifested in the paleness of the skin and of the linings of the mouth and eyelids, and is due to the impoverishment of the blood from the blood-sucking habit of the worms. The edema is manifested in a swelling of the pendant portions of the body, especially of the portion under the jaw, causing what is called "bottle jaw." Sheep may become emaciated and finally die.

If the fourth stomach of a sheep infested with stomach worms is opened (the fourth stomach is the one to which the upper end of the small intestine attaches), the worms can usually be seen as wriggling red objects. When the contents of the stomach are poured out many of the worms will usually remain attached to the lining of the stomach. A little careful washing will reveal them if they are covered by the stomach contents. Close investigation of the lining of the fourth stomach will also reveal the pin-point punctures caused by the bites of the worms. There are usually a number of these for every worm, as the worm has the habit of attaching at one point for a time and then moving away and attaching at another point, leaving the old point of attachment bleeding for some time. The carcass of a sheep seriously infested with stomach worms is likely to be emaciated and the meat pale.

Treatment.—A treatment which is satisfactory for the removal of stomach worms under most conditions is a 1 per cent solution of copper sulphate in water. A dose which has been found satisfactory is 100 c. c. (about 3 ounces) for yearlings and older sheep and half as much for lambs 3 months old or older. To make this solution, dissolve one-fourth pound of copper sulphate in 1 pint of boiling water, then add cold water to make a total of 3 gallons of the solution. Occasionally complaints are received that copper sulphate has not controlled stomach worms satisfactorily. Recent investigations in Texas and Australia showed that a 2 per cent solution of copper sulphate is more effective for the removal of stomach worms than a 1 per cent solution and that this strength solution may be safely administered to sheep. To make a 2 per cent solution, dissolve one-half pound of copper sulphate in 1 quart of boiling water, then add cold water to make a total of 3 gallons of solution. The dosages recommended are 60 c. c. (2 ounces) for mature sheep and 30 c. c. for lambs.

Porcelain or enamel-ware receptacles should be used for the solution, as bluestone (copper sulphate) will corrode metal. This amount will dose 100 adult sheep, allowing 10 per cent for waste. Use only clear blue crystals of copper sulphate, discarding the pieces that have turned white. Crushing the crystals will hasten solution. In dosing, one may use a rubber tube with a funnel on one end and a piece of metal tube at the other. The metal tube is placed in the sheep's mouth and the solution slowly poured through the funnel. If large numbers of sheep are to be treated, the apparatus pictured in Figure 25, or something similar to it, may be used. The copper-sulphate solution is fed from a high reservoir, by siphoning or by a tube or spigot near the bottom, through a rubber tube into an open graduated glass tube, which may be made from a large olive jar, and allowed to escape in measured doses through the other rubber tube to the metal tube in the sheep's mouth. Instead of an open graduated glass tube, a large bottle or jar may be used if a third tube is put in the jar, through the cork, one end being open to the outside and the other opening near the bottom of the inverted jar, to equalize air pressure. This is shown in Figure 25. The flow into and out of the glass tube is controlled by pinchcocks, one person attending to this and one holding the metal tube in the sheep's mouth. The sheep should remain on all four legs, with the head held horizontally while it is being drenched, which decreases the danger of getting the drench into the lungs and killing the sheep. The solution should be allowed to flow slowly and the metal tube be moved about slightly in the mouth at the same time in order to keep the sheep swallowing. It is essential that the copper-sulphate solution be made up accurately, be given in suitable doses, and be administered with care, and it is advisable to have a competent veterinarian give this treatment or the ones noted below in order to insure a maximum degree of safety.

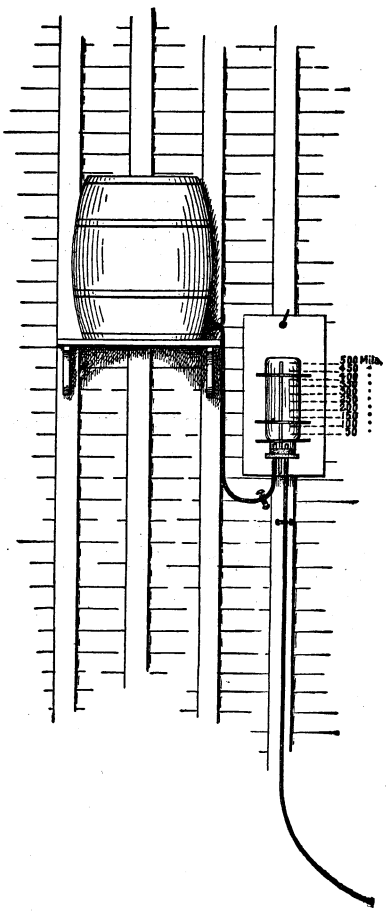

FIGURE 25.—Dosing device for administering copper-sulphate solution

The sodium-arsenite and copper-sulphate mixture and the copper-sulphate and nicotine-sulphate solution, recommended for tapeworms, are also effective against stomach worms.

Tetrachlorethylene in doses of 2.5 to 3 c. c. for lambs and 5 c. c. (1.3 dr.) for adult sheep in an equal bulk of dry Epsom salt, given in capsule, has been found in experimental tests to be an effective remedy for stomach worms in sheep. Carbon tetrachloride may be substituted for tetrachlorethylene provided the feeding precautions outlined under "The nodular worm," page 39, are observed.

Recent investigations by the United States Bureau of Animal Industry have demonstrated that phenothiazine has unusual promise as an anthelmintic for the removal of various kinds of gastrointestinal roundworms from sheep. The dosage of commercial phenothiazine is 25 grams for sheep and 15 for lambs. Individual doses may be given as drenches or in capsules or all the animals may be treated at one time by mixing the drug in the feed. Experimental and field trials have shown that sheep parasites may be effectively controlled by allowing the animals free access to mixtures of 1 part of phenothiazine and 9 parts of loose salt. This method of medication is especially well adapted for use throughout the grazing season.

Prevention.—Preventive measures are based on the life history. We know that the disease is spread by eggs, produced by the female worm, which escape in the manure on to the pastures. Infested sheep must be regarded as a danger to young and uninfested sheep. The manure from the infested sheep is likewise dangerous. Consequently, young animals and uninfested sheep should be separated from older or infested animals and not exposed to contact with the manure from these animals. Furthermore, pastures which have been used by infested animals are dangerous to young animals and uninfested sheep. When animals that have stomach worms, either in a light or heavy infestation, are put on clean pasture, the eggs of the stomach worm will hatch on the ground and the infective stage of the worm will be present on the grass in considerable numbers in from 10 to 20 days, or even earlier in warm weather. The longer the sheep are on that pasture under ordinary weather conditions the more dangerous it will become from the increasing number of worms. To prevent setting up dangerous infestations, it is advisable that sheep be moved every two weeks to clean pasture. Inasmuch as pastures probably remain infected for about a year after sheep, goats, or cattle are moved from them, the program of moving sheep to new pasture, where permanent pastures are used, is a rather difficult one and calls for more land than is usually available. Consequently a modification of this program is necessary.

The first essential is to protect the lambs. Young animals are more susceptible to parasitic infestation than older ones. They also suffer more from parasites when they are infected. Growth must be made during youth; it can not be made up in mature years. Parasites interfere seriously with growth and lead to the production of runts. Consequently the safest pasture should be furnished to the lambs, the older sheep taking the more dangerous pasture, if it is necessary for sheep to go back to old pasture within a year. Hillside pastures are likely to be safer than bottom land, as they benefit by the cleansing action of heavy rains and the following run-off, as well as holding less moisture. Lack of moisture is very unfavorable to the worms. Rich bottom pastures, on the other hand, are least likely to have an

infection washed off and are likely to have eggs and larvae from the hillsides above washed on to them. The more abundant moisture, moreover, is highly favorable to the worms. It is precisely these bottom pastures which are apt to be used for young animals, because they present the best growth of grass and are most attractive.

In rotating pastures to keep down stomach worms, the sheep may be moved over cornfields, hayfields, and stubble of various sorts. During freezing weather, the eggs and nonresistant early stages of the young worm on pasture diminish as they are killed by freezing, so that the pastures at this time, while still infected, do not become increasingly dangerous. Plowing is a means of controlling infestation, the young worms being turned under and buried; apparently they do not get back to the surface in numbers sufficient to cause serious trouble. Such plowed land may be sown to forage crops and the sheep turned on these crops with safety. When different kinds of stock are rotated on pastures, sheep may safely follow horses or swine, but not cattle or goats, as these latter also may be infected with stomach worms and a number of other worms common to sheep, goats, and cattle.

In experiments formerly conducted by this Bureau at Vienna, Va., it was found highly beneficial to dose sheep with copper-sulphate solution once every three or four weeks throughout the year, sheep thus treated showing no losses from stomach worms and making decided gains in wool and mutton over sheep kept under the same conditions but not treated. This appears to be the best control measure for use on sheep kept under the usual farm conditions. On Southern pastures of high carrying capacity, it is necessary to dose every two weeks if heavy stocking is practiced.

THE SMALL TRICHOSTRONGYLES

Besides the common stomach worm, *Haemonchus contortus*, and the thread-necked strongyles, *Nematodirus* spp., sheep and goats are often infested with and sometimes suffer severely from infestation with a number of smaller trichostrongyles. The worms, included in this group are *Ostertagia circumcincta*, *O. trifurcata*, *Cooperia curticei*, *C. oncophora*, *Trichostrongylus axei*, *T. vitrinus*, *T. colubriformis*, and *T. capricola*.

The medium stomach worms or brown hair worms

Location.—The medium stomach worms, *Ostertagia circumcincta* and *O. trifurcata*, are found in the abomasum or fourth stomach, generally in the end of the stomach nearest the small intestine.

Appearance.—These worms are small and hairlike, about one-half inch long, and of a brownish color.

Life history.—The life history of these worms is direct. The eggs are deposited by the female worms in the fourth stomach and pass out with the manure. Under favorable conditions of temperature and moisture these eggs hatch in about a day, and infective larvae develop in from 5 to 6 days. The infective larvae are taken into the body of the host animal in grazing; and, after reaching the fourth stomach, the larvae penetrate into the wall of this organ. Further development to the adult stage takes place in about 15

days, and eggs are found in the manure of infested sheep about 18 days after experimental infection.

Symptoms and lesions.—As a result of the penetration of the larvae the stomach wall becomes inflamed, dotted with small, white elevated areas and marked with minute hemorrhages. These affected areas increase in size and become nodular in appearance as the worms grow. With maturity the worms emerge from these nodules and the nodules recede and disappear.

Inasmuch as under natural conditions infestation with *Ostertagia* is usually accompanied by infestation with the common stomach worm, *Haemonchus contortus*, as well as with infestation with other worms, it is rather difficult to describe any symptoms which can be specifically referred to infestation with *Ostertagia* spp. Sheep primarily infested with *Ostertagia* spp. are said to show progressive loss of condition, accompanied by intermittent diarrhea and stunting.

Treatment.—The mixture of copper sulphate and nicotine sulphate as described on page 17, possesses some value for the removal of medium stomach worms, but it is not satisfactory under all conditions. Recent investigations carried out in the Bureau of Animal Industry indicate that phenothiazine is at least partially effective for the removal of these parasites. (For dosages, see under Treatment, pp. 32 to 34.)

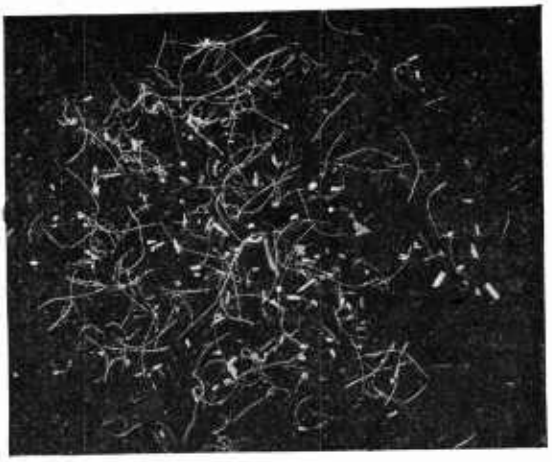

FIGURE 26.—Small trichostrongyles of sheep. (Natural size)

The small stomach and intestinal worms

Location.—Several species of small trichostrongyles (*Trichostrongylus axei*, *T. colubriformis*, *T. vitrinus*, and *T. capricola*) are found in the stomach and small intestine of sheep and goats. *Trichostrongylus axei* occurs for the most part in the fourth stomach, while *T. colubriformis*, *T. vitrinus*, and *T. capricola* are generally found in the small intestine, *T. capricola* occurring more frequently in goats than in sheep.

Appearance.—These trichostrongyles are small, hairlike worms about one-fourth to one-third of an inch long. (Fig. 26.) They are usually present in fairly large numbers, but on account of their small size they may be overlooked on post-mortem examination. The easiest way to find them is to wash out the first 20 feet of the small intestine in a glass dish and examine the washings against a dark background. Another method is to scrape the lining of the small intestine and to examine the scrapings.

Life history.—The life history of these small trichostrongyles is similar to that of the common stomach worm. The eggs pass out

with the excreta, hatch on the ground, and develop to infective larvae, the length of time required for development depending upon such conditions as temperature and moisture. The infective larvae are taken in by sheep in grazing and develop in the host animal to mature worms in about 21 days. The life histories of these worms differ from that of the common stomach worm in the extraordinary resistance of the embryonated eggs to drying. These eggs have been shown to be able to survive drying for 15 months under experimental conditions. This ability of the embryonated eggs to withstand long periods of drying is of great importance in connection with the life history and with a possible control of pasture infection. It enables such eggs to survive long periods of drought and resume their development as soon as sufficient moisture becomes available, thus continuing pasture infections which might otherwise be terminated as a result of long-continued dry weather.

Symptoms and lesions.—There are no noticeable gross lesions associated with trichostrongylosis (infestation with trichostrongyles). An increased amount of mucus in the first 10 feet of the small intestine and congestion of the wall of the small intestine have been reported by some investigators. The clinical symptoms are those usually associated with worm infestations, namely, loss of condition, unthriftiness, and anemia. The outstanding clinical symptom is a more or less persistent diarrhea, the feces being soft and pasty in the beginning of the infestation but rapidly becoming fluid and watery as the disease progresses. The disease, referred to by the Australians as "black scours," may last for weeks or even months, the younger animals, 3 to 18 months old, being the chief sufferers. There is at first little evidence of anemia, but as the disease progresses the anemia becomes more marked. In contradistinction to what occurs in infestation with the stomach worm there is, in pure infestations, no accumulation of fluid under the jaw or in the abdominal cavity, these conditions being commonly referred to as bottle jaw and potbelly. On post-mortem examination there is extreme emaciation, as evidenced by the wasting of the musculature and the negligible quantity of fat, but the blood does not show the pale, watery anemia commonly present in severe stomach-worm infestations.

Trichostrongylosis may be differentiated from haemonchosis, a disease due to infestation with the common stomach worm *Hæmonchus contortus*, as follows: Trichostrongylosis is essentially a slow, protracted disease of young animals, especially lambs and yearlings, which appears shortly after weaning and continues through the summer and winter. It is marked by unthriftiness, pronounced diarrhea, progressive weakness, and loss of appetite. Anemia is not noticeable at first but becomes evident as the disease progresses; potbelly and bottle jaw are absent in pure infestations. Infestation with common stomach worms, on the other hand, is a rapidly fatal disease affecting all classes of animals, accompanied by no noticeable stunting or consistent scours, that is, scouring may or may not be present, or may be intermittent. Anemia appears early in the course of the disease, and potbelly and bottle jaw are commonly present.

Bone weakness, manifested by lameness and spontaneous fracture of the leg bones, especially of the femur and the humerus, has been reported occasionally in sheep heavily infested with small trichostrongyles.

Treatment.—Heretofore, repeated treatments with copper sulphate and nicotine sulphate, as described on page 36, offered the only means of medicinal control. However, recent evidence indicates that 25 grams of phenothiazine per adult sheep is effective for the removal of the small trichostrongyles. (For details see under Treatment, pp. 32 to 34).

Australian veterinarians emphasize that the course of this disease is markedly influenced by nutritional conditions. Losses from trichostrongylosis occur during the dry summer months when the grass becomes short.

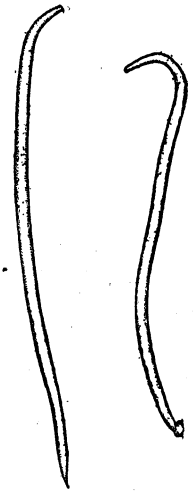

FIGURE 27.—Nodular worm (*Oesophagostomum columbianum*). Right figure, male; left, female. Magnified five times. (From Ransom)

THE NODULAR WORM

Location.—The adults of the nodular worm (*Oesophagostomum columbianum*) live in the large intestine of the sheep. The larval worms live in nodules in the wall of the large and small intestines and occasionally make their way to the mesenteric lymph glands, the omentum, or the liver. The nodules are most numerous in the wall of the large intestine.

Appearance.—The female worms attain a length of 15 mm. (about five-eighths inch), the males being a little shorter. (Fig. 27.) Both sexes have a characteristic solid white body. The head is bent over and forms a hook with the body.

Life history.—The details of the life history are not completely known. The eggs from the female in the large intestine of the sheep are passed in the manure. The eggs hatch and the young worms undergo a certain amount of development on the pasture, becoming infective for sheep. When swallowed by sheep, the larvae enter the walls of the large and small intestines. The time during which the larvae remain in the wall of the intestine varies considerably in different animals, but in general the larvae migrate from the wall to the lumen of the intestine within from 1 to 6 months after infection, and they reach maturity in the course of a month after leaving the nodules. Larvae can be found only in the smaller and more recent nodules. Subsequently these cysts commonly reach a considerable size and contain a necrotic material, usually yellowish or greenish in color, cheesy in consistence, or often hard and almost stonelike. (Fig. 28.) Those larvae which get to the mesenteric lymph glands, the omentum, and the liver probably die in these places.

Distribution.—This parasite was originally present in this country only in the Southern and Eastern States, but it has been spreading westward, probably with infested sheep introduced into western localities for breeding purposes, and there is reason to fear that it will become generally distributed over the country. It has become rather common in the Middle West, and is a serious pest in the Northeastern States. It is still uncommon in the Rocky Mountain States, and as yet has not been reported from a number of these States.

Symptoms and lesions.—According to one investigator (Curtice), the symptoms of this disease may be only those of general debility—a pale mucous lining of the eyelids and mouth, emaciation, dry wool, etc. In severe cases diarrhea and emaciation may be excessive. In some places sheep raising has been abandoned on account of the damage done by this worm. It is evident that the injury due to numerous intestinal nodules, which prevent large areas of the intestine from functioning properly in the work of secretion and absorption, act as persistent irritants to the sensitive nervous system of the digestive tract, and serve to supply poisonous material from worms, bacteria, and dead tissue to the adjacent absorbing tissues of the intestines, can not fail to have a bad effect on the host animal. The resultant loss is seen in less meat and wool, decreased growth, and poorer quality of the animals, and the unfitness of nodular intestines, or so-called "knotty guts," for sausage casings.

FIGURE 28.—Sheep intestines showing lesions of nodular worm disease

The post-mortem lesions are easily seen, the principal ones being the nodules, which may be larger than good-sized peas, on the walls of the large and small intestines, or in the mesenteric lymph glands, the omentum, or the liver. The nodules may be small, elevated objects, or they may be larger and contain cheesy or limy matter, white, greenish, or yellowish in color. These nodules are sometimes mistaken for lesions of tuberculosis, a rare disease in American sheep.

Treatment.—As yet we have no satisfactory treatment for the removal of the larval worms which are in the nodules and beyond the reach of any remedies. There is some difficulty in getting a suitable drug past the four stomachs and into the large intestine in sufficient strength to remove these worms. Experiments in the Bureau of Animal Industry have indicated that tetrachlorethylene in doses of 2½ to 3 c. c. for lambs and 5 c. c. for adult animals, given in a capsule, with an equal bulk of dry Epsom salt, repeated at intervals of four weeks, will in two or three months sometimes remove all

the nodular worms present in a sheep. Repeated treatments will also remove many of the thread-necked strongyles and related worms and some whipworms. Carbon tetrachloride may be substituted for tetrachlorethylene and administered in the same manner. Ten days or two weeks before sheep are to be dosed with carbon tetrachloride they should be placed on a ration high in available calcium in order to avoid intoxications which sometimes follow where there is not a sufficient reserve of ionized calcium in the system. Such a ration may include steamed bonemeal, ground limestone, alfalfa meal, and alfalfa or clover hay. Abrupt changes of feed should be avoided prior to the administration of carbon tetrachloride; treatment within a few weeks after a change of feed may cause injury or death. It is advisable to produce prompt purgation in using carbon tetrachloride. The treatment should be administered by a competent veterinarian.

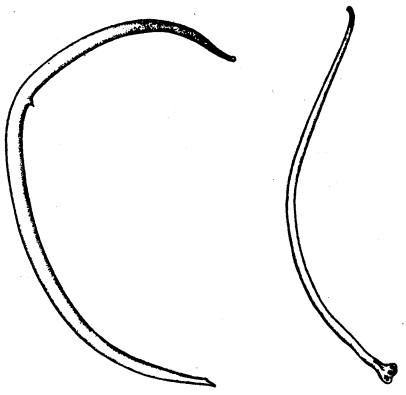

FIGURE 29.—Sheep hookworm (*Bunostomum trigonocephalum*). Female at left; male at right. Magnified five times. (From Ransom.)

South African workers report good results from a treatment consisting of a mixture of copper arsenate, 2 parts; calcium hydroxide, or slacked lime, 3 parts; and copper tartrate, 5 parts. The dose of this mixture is 1 gram, or 15 grains, for lambs 3 to 6 months old; 1.8 grams, or 27 grains, for lambs 6 to 18 months old; and 2.5 grams, or 37.5 grains, for animals over 18 months old. Two doses are given on consecutive days, and each treatment is preceded by the administration of 2.5 c. c. of 10 per cent solution of copper sulphate. The treatment is administered as follows: The sheep's mouth is opened wide and the copper sulphate solution is poured alongside the tongue so that it runs down into the throat. Without closing the sheep's mouth the proper dose of the copper arsenate, lime, and copper tartrate mixture, which is made up in the form of a powder, is placed on the back of the tongue immediately after the copper sulphate solution is given. The treatment is repeated the next day. Sheep should not be given grain or be permitted access to a salt lick from two days before to one day after the treatment. If the pasture is dry, green feed should be furnished for a few hours before each dosing. Sheep must not be kept from feed and water before treatment. They may graze immediately after treatment but should have no water for one to two hours after treatment.

Phenothiazine, as recommended on page 34, is an effective treatment for the removal of the adult nodular worms from sheep. Winter medication, with this drug in one or two treatments of the breeding flock, has proved particularly successful in areas having long seasons of freezing weather. Another method which is especially applicable in warmer areas consists in allowing sheep on pasture free access to mixtures of 1 part phenothiazine and 9 parts salt.

Prevention.—Pasture rotation, as in the case of the stomach worm, is a valuable control measure. Dalrymple found that he could practically prevent the nodular worm infection of lambs by raising them in bare lots, where there would be no temptation to graze and where surroundings would be unfavorable for the development of the parasite. The ewes were let into these lots whenever necessary to nurse the lambs. The lambs were given other feed from raised racks and watered from raised troughs. The racks and troughs were protected from fecal contamination and the floor of the yard cleaned frequently to keep it free from litter and manure, thereby preventing the development of the eggs in the manure in the yards. As in most parasitic diseases, the young animals suffer more than older ones, and measures must be directed especially to the protection of the lambs. If persisted in, these measures and pasture rotation should keep the infestation down to a point where it does little damage.

THE SHEEP HOOKWORM

Location.—Hookworms of sheep (*Bunostomum trigonocephalum.* Synonym, *Monodontus trigonocephalus*) are found in the small intestine.

Appearance.—The female hookworm attains a length of 2.6 centimeters (about 1 inch), the male attaining a maximum length of 1.7 cm. (Fig. 29.) The worms are about one-half to three-fourths as thick as an ordinary pin. At the head end is a mouth capsule armed with teeth. The tail of the male is expanded and flattened.

Life history.—The life history of the sheep hookworm has recently been investigated to some extent. It is about as follows: The eggs produced by the female worm in the intestine of the sheep pass out in the manure and hatch on the pasture. Under favorable conditions of temperature and moisture the young worms develop through two molts to a resistant form capable of infecting sheep. The infective larvae are swallowed by sheep in grazing. When they reach the intestine they develop into adult worms, and the two sexes mate.

Distribution.—This parasite is common in sheep in the Southern States and has been found as far north as New York. Additional studies in various localities would doubtless show a wider distribution. It is apparently fairly common in Europe.

Symptoms and lesions.—The symptoms resulting from infestation with the sheep hookworm have not received much attention, but its habits are similar to those of the hookworm in man and in the dog, and these are known to cause very serious damage, so that there can be little question of the damage that hookworms may do in sheep. The worms are bloodsuckers, with the habit of attaching for some time at one place and then moving to another, leaving the first puncture still bleeding. This bleeding persists for some time, as the result of a secretion from the mouth parts of the worm which has the power to dissolve the blood corpuscles and prevent clotting.

With hookworms in general it is not uncommon to see 10 or 12 hemorrhages associated with a single worm. This loss of blood results in its impoverishment, as well as in a net loss in amount of blood present. This in turn causes a seepage of the thinned blood

out of the blood vessels and into the tissues, causing watery swellings, or edema, of the pendant portions of the body, as well as an associated condition or dropsy, within the body. With the impoverishment of the blood the nutrition of the animal is impaired—a very serious matter with young animals. We may safely infer that there is serious damage to the sheep's nervous system, preventing its

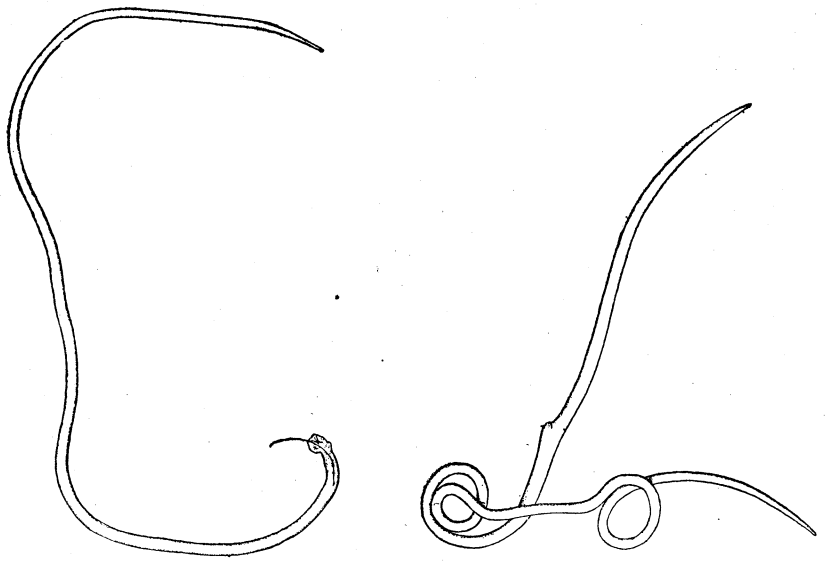

FIGURE 30.—Thread-necked strongyle (*Nematodirus spathiger*). Left, male; right, female; about 10 times natural size. (From Ransom)

smooth functioning and making for poor animals and poor offspring.

The things that may be looked for in connection with hookworm disease are paleness of the mucous lining of the eyelids and mouth, pale skin, dry wool, watery swellings under the jaw and along the abdomen, and a general condition of unthriftiness. The condition is very similar to that found in stomach-worm disease, as the two worms affect the host animal in substantially the same way. As it is usually complicated with stomach-worm disease, hookworm infestation is not apt to be recognized as a distinct disease. The only way to make a satisfactory diagnosis between the two conditions is by a post-mortem examination of the fourth stomach and the small intestine in order to ascertain which of the worms is present. In some cases both species of worms will be found, and the results may be attributed to the mixed infestation. The lesions caused by the hookworm are red spots, or small hemorrhages, in the small intestine, while similar spots in the fourth stomach are caused by stomach worms.

Treatment.—The bluestone and tobacco or bluestone and nicotine sulphate solution recommended for tapeworms (pp. 17 and 18) is partially effective for the removal of these worms.

Tetrachlorethylene in doses of 5 c. c. in capsule with an equal bulk of dry Epsom salt is usually effective for the removal of hookworms from infested sheep.

Phenothiazine, when used as recommended on page 34, is approximately 90 per cent effective for the removal of hookworms from sheep.

Prevention.—Pasture-rotation methods, as outlined under the subject of stomach worms, will be of great value in controlling sheep hookworms. Proper disposal of the manure, which carries the eggs of the worm, is also important. In view of the fact that this worm possibly enters the sheep through the skin of the legs as well as through the mouth while the animal is grazing, boggy land and loose, wet, sandy soil may be looked on with suspicion as apt to convey the infection by bringing the larvae in contact with the skin in mud or wet sand.

THE THREAD-NECKED STRONGYLES

Location.—The thread-necked strongyles (*Nematodirus filicollis*, *N. spathiger*, etc.) are found in the small intestine.

Appearance.—These are reddish worms, the anterior portion more slender than the posterior. The head and the neck end are transversely striated. In *N. spathiger* (fig. 30), the male worm attains a length of 1.5 cm. (⅗ inch). The female attains a length of 2.3 cm. (about 1 inch).

Life history.—The eggs produced by the female worm pass out in feces, and an embryo develops in them. This worm molts twice in the shell, the skin that separates at the second molt, however, remaining on the larva. The larva hatches under the influence of alternate moistening and drying or of temperatures of 24° to 32° C. (75° to 90° F.). Like the stomach worm, the ensheathed larva then ascends a blade of grass under favorable conditions of temperature and moisture, and is taken in by sheep as they feed. These larvae are very resistant to cold and drying and have also been found to live in water for over 11 months. In the intestine of the sheep the larvae develop to adult worms.

Distribution.—At least one species of these worms (*N. spathiger*) appears to be quite common in sheep in the United States.

Symptoms and lesions.—When present in small numbers, it is unlikely that these worms do much damage, but sheep infested with large numbers have been found to be unthrifty. So far the only symptoms that may be attributed to them are those commonly associated with gastrointestinal parasitism in general—those of malnutrition. No definite lesions have yet been described for this worm.

Treatment.—Tetrachlorethylene is effective in removing thread-necked strongyles when used in repeated doses during a considerable period of time. For adult animals the drug should be given in doses of 5 c. c. in capsule with an equal bulk of dry Epsom salt. Carbon tetrachloride may be substituted for tetrachlorethylene. When carbon tetrachloride is used, the feeding precautions outlined under The nodular worm, page 38, should be observed.

Prevention.—The same measures that are of value against stomach worms probably will be of value against the thread-necked worms.

THE WHIPWORM

Location.—The whipworm (*Trichuris ovis*) occurs in the large intestine, usually in the cecum, but rarely elsewhere in the digestive tract.

Appearance.—The body of this worm is thick posteriorly and very slender anteriorly, the anterior portion of the body being two or three times as long as the posterior portion, from which fact it receives the name of whipworm. The thick portion is comparable to a whip handle and the thin portion to a whiplash. (Fig. 31.) The male is 5 to 8 cm. (2 inches to over 3 inches) long, with the anterior portion of the body three times as long as the posterior portion. The male spicule is 5 to 6 mm. long and has a long sheath covered with spines and terminating in a bulbous enlargement. The female is 5 to 7 cm. long, with the anterior portion of the body twice as long as the posterior portion. The eggs of the whipworms are characteristically lemon-shaped.

FIGURE 31.—Whipworms (*Trichuris ovis*). Female at left; male at right. Magnified five times. (From Curtice)

Life history.—So far as is known this worm has a simple life history. The eggs produced by the adult worm pass out in the feces, and an embryo develops in each egg under suitable conditions of temperature and moisture. When these eggs are swallowed by sheep the embryos develop to adult worms.

Distribution.—These worms are very common in sheep in the United States and many other countries.

Symptoms and lesions.—It has been found that whipworms in man set up a low-grade inflammation, with distinct discomfort and distress. In animals, inflamed areas are quite commonly found where whipworms attach. The head end of the worm is usually found sewed into the mucosa. Recent investigations indicate that the larval whipworm enters the mucosa by means of a piercing lancet in the mouth, the lancet being lost in later stage of development. There are no well-defined clinical symptoms for whipworm infestation in sheep. On post-mortem examination the thick posterior ends of the worms will be found in the lumen of the intestine, the anterior ends being in the mucosa.

Treatment.—Tetrachlorethylene and carbon tetrachloride may be effective in removing whipworms when used in repeated doses. In using carbon tetrachloride the feeding precautions outlined under The nodular worm, page 38, should be observed. For adult animals

the drugs should be given in doses of 5 c. c. in capsules with an equal bulk of dry Epsom salt.

Prevention.—Prevention of whipworm in sheep is a matter of sanitation and pasture rotation. The same measures that are useful in controlling stomach worm will be of value in controlling whipworm.

THE THREAD LUNGWORM

Location.—The thread lungworm (*Dictyocaulus filaria.* Synonym, *Strongylus filaria*) is found in the air passages, bronchi, and bronchioles of the lungs.

Appearance.—These are rather long worms, easily observed. They are white and the intestine shows a dark hair line throughout the length of the worm. (Fig. 32.) The male is 3 to 8 centimeters (from more than 1 inch to more than 3 inches) long. The female is 5 to 10 centimeters (2 to 4 inches) long, with a straight, conical tail. The eggs contain an embryo when they leave the body of the mother worm.

Life history.—The eggs deposited by the female hatch in the lung of the host animal, probably in the course of 24 hours, and larvae are expelled in coughing, or swallowed and passed in the feces. The newly hatched larva has a rounded head and a rather blunt tail. It molts twice in the course of the next few days, the time varying with temperature and moisture, and, under ordinary circumstances, is infective within 10 days. This larva then climbs up grass blades, when they are wet and the weather is warm, as do the larvae of the stomach worm and thread-necked worm, and here it is taken in by grazing sheep and makes its way to the lungs. In the course of a month the sheep begins to show symptoms of lungworm, and in about five weeks embryos appear in the manure.

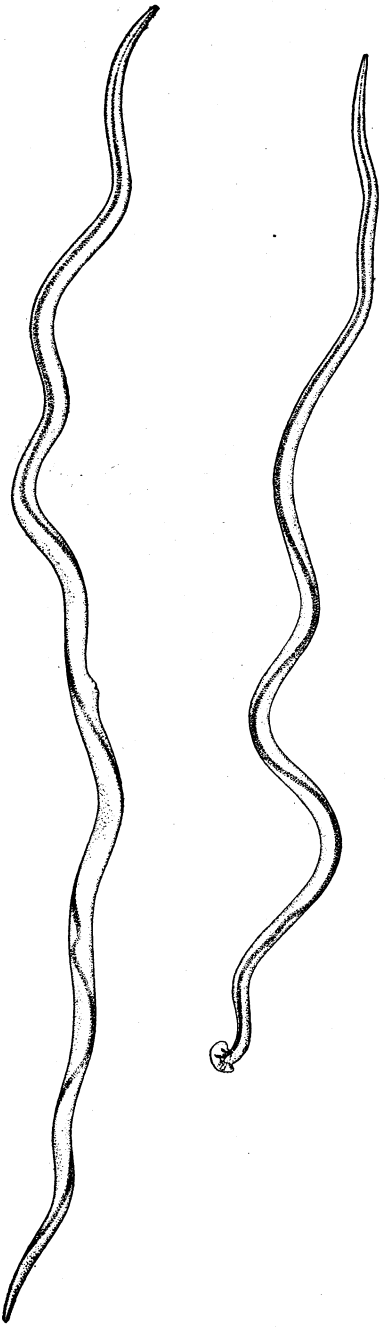

FIGURE 32.—Thread lungworms (*Dictyocaulus filaria*). Male at right; female at left. Magnified three times. (From Curtice)

Distribution.—These worms are widely distributed over the world and are comparatively common in the United States, especially in the South and where there is plenty of moisture and warmth.

Symptoms and lesions.—The worms and their eggs and larvae set up an irritation of the lung tissue at the point where they are located, causing inflammation and a catarrhal condition, the latter manifested in the production of a frothy mucus, sometimes containing traces of blood. Bacterial infection of the weakened lung tissue may follow, and the lungs may show pus and consolidated areas. Usually the latter conditions are not present. The symptom first noted is a husky cough, and if the invasion is extensive this may be followed by difficulty in breathing. If left alone, some animals are liable to die of weakness or suffocation. The disease may be diagnosed from the clinical symptoms by an experienced veterinarian or stockman who is familiar with it; the diagnosis may be confirmed by a microscopical examination of the feces or of the saliva from the back of the tongue, though occasionally one may not find larvae, especially in recent infections. On post mortem the lungs show inflamed patches, and the worms can be found in the air passages. There is usually a diarrhea.

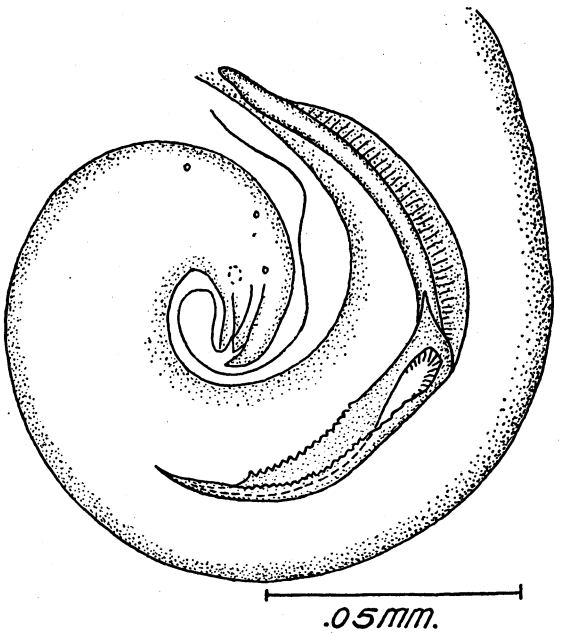

FIGURE 33.—Hair lungworm (*Muellerius capillaris*). Tail of male, viewed from side. Greatly magnified. (From Cameron)

Treatment.—Most of the treatments by intratracheal injections that have been used for lungworm disease of cattle are not very satisfactory and are rather dangerous to sheep. A treatment which has been used on a large number of animals with reports of satisfactory results consists in injecting chloroform in 3 c. c. doses (about three-fourths of a teaspoonful) into the nostrils of the sheep by means of a medicine dropper, the head of the sheep being tilted back. The nostrils of the sheep are then held with the fingers until the animal is somewhat groggy. This treatment may be repeated at intervals of three to five days, if necessary, for a total of not more than three doses. It is recommended that a dose of Epsom or Glauber salt be given two hours after the treatment.

Nursing treatment appears to be the safest and most satisfactory treatment in most cases. Sheep should be taken off wet pasture and placed on high, dry pasture or put up and fed dry feed. A safe supply

of drinking water and plenty of good feed are of value in tiding the sheep over the critical stages of the disease and allowing the worms to die out.

Prevention.—The same general rules that apply in the case of the stomach worm apply here. Sanitation and pasture rotation, isolation of infested animals, and special precautions in regard to the pasturing and watering of lambs and young animals are all measures of value.

THE HAIR LUNGWORM

Location.—These worms (*Muellerius capillaris*) occur in the small bronchioles and in the lung tissue.

Appearance.—Hair lungworms (figs. 33 and 34) are much smaller than the thread lungworms. The male is about 12 mm. (one-half inch) long and the female about 19 mm. (three-fourths of an inch) long.

Life history.—The life history of the hair lungworm is indirect; that is, an intermediate host is required in its life cycle. The embryo or larva passes out of the body with the manure and enters a land snail in which the parasite reaches the infective stage. Many kinds of land snails serve as intermediate hosts.

Distribution.—The parasite is widely distributed and has been found to be fairly common in the United States. It is perhaps less common than the previous species or possibly is found less often because it is smaller.

Symptoms and lesions.—These worms occasion various forms of verminous pneumonia. The adult worms cause a lobular pneumonia; the eggs and larvae cause a diffuse pneumonia, or when aggregated in the pneumonic areas may cause a pneumonia with areas resembling tubercles. These areas show as grayish-yellow tumors, which may attain a diameter ranging from a few millimeters to 2 centimeters (four-fifths of an inch). Careful post-mortem examination of these pneumonic areas will disclose the reddish worms, and the eggs and larvae may be found by microscopic examination of such tissue. The weakened tissues afford lodging for disease-producing bacteria, sometimes leading to pus formation, in which case the evil effects are considerably increased. Sheep will survive an infection with worms which prevents only a small amount of lung tissue from functioning, but heavy infections reduce the amount of living tissue available for breathing to an extent that often proves fatal, and bacterial complications add to this and to the toxic material which is absorbed to the injury of the animal.

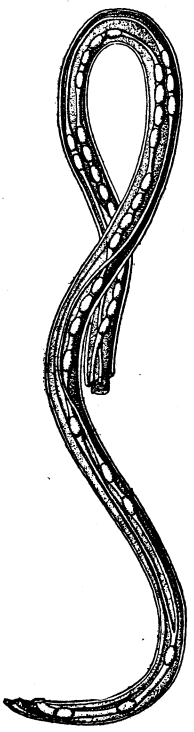

FIGURE 34.—Hair lungworm (*Muellerius capillaris*). Tail of female, viewed from side. Magnified about 20 times. (From Curtice)

Treatment.—We have little evidence in regard to a satisfactory treatment for this worm, but the nursing treatment given for the preceding species would probably be the best procedure.

Prevention.—In view of the fact that land snails are a necessary link in the life history of this worm, the obvious method of preventing infestation of animals with this lungworm is to keep sheep away from places where snails are found. Snails and slugs require moisture and occur in low, damp, moist spots in the pasture. Therefore, in areas where this trouble appears, animals should be pastured on high, dry ground whenever practicable. The use of mixtures of bonemeal, lime, and salt may serve by preventing mineral deficiencies, to keep sheep from eating snails to supply missing minerals.

OTHER INTERNAL PARASITES

Various other kinds of roundworms, flukes, tapeworms, Protozoa, and arthropods, in addition to those discussed here, may infest sheep. They are omitted because, as far as is known, they are relatively less important.

OVERSTOCKING

Overstocking is of major importance in the causation of parasitism and should be avoided whenever possible. The more infested sheep there are on a given area, the more manure and the more worm eggs and infective larvae there will be. Also there will be greater chances that the sheep will swallow the infective eggs or larvae in grazing. As the number of sheep on a given area increases, the quantity of feed available to each sheep diminishes and this in turn renders the animal more susceptible to infection. Overstocking may be avoided, (1) by the use of temporary pastures as described in Farmers' Bulletin 1181, issued by the Department, or (2) by the judicious rotation of permanent pastures. The use of temporary pastures provides a succession of fresh forage crops and thus aids the ewes to produce and maintain a maximum milk flow for the lambs. Since lambs as well as the young of other domestic animals suffer more severely from parasitic infestation than the older animals, this increased milk flow is of greatest importance. With abundant milk available from the ewes the lambs will not graze as much as when they are completely dependent upon the pasture for all of their food, and an abundant supply of milk enables them to grow faster and to combat any parasitic infestation which they may acquire.

The use of temporary pastures as described in the above-mentioned bulletin is also of material assistance in preventing worm infestation because the plan requires that the sheep, especially the lamb flock, do not go on a field a second time unless the land has been plowed in the interim or time enough has elapsed to cause the death of large numbers of infective larvae left on the field grazed by infested sheep. It has been shown experimentally that the greatest number of infective larvae of the common roundworm parasites of sheep die within a few weeks after the infested sheep have been removed from the pasture. While it is true that some infective larvae may live for a long time, the important fact to remember is that only a small percentage of the worm eggs deposited on the pasture develop into infective larvae and that large numbers of them die within a comparatively short time after they have reached the infective stage.

The judicious rotation or alternation of permanent pastures can also be utilized to avoid overstocking and its inherent dangers. If a sufficient number of pastures is available or if the area is large enough to be profitably divided by the erection of temporary or permanent fencing, the proper rotation of the separate fields can be used to avoid overstocking any one area. The flock should be moved from field to field as often as conditions permit. As in the temporary pasture scheme, one pasture should not be used more than two weeks at any one time, especially during the warm part of the season, and a period of from 6 to 8 weeks should elapse between successive grazing periods. It should be remembered, however, that while these methods are useful in preventing excessive parasitic infestation, they are not cure-alls, and do not relieve the flock owner from the necessity of watching his animals for evidence of parasitism. Even with rotation of pastures or the use of temporary pastures it may become necessary to supply medicinal treatment.

If overstocking cannot be avoided the danger of excessive parasitism can only be dealt with by regular and persistent medicinal treatment. Special attention should be given to the winter and early spring treatment of the flock. In the greater part of the farm flock area the winters are sufficiently cold to prevent the development of the worm eggs that may be deposited on the ground. When the sheep are removed from the pasture in the fall most of the infective larvae left on the pasture will die before the arrival of the next pasture season. In case the sheep are left outdoors all winter, the worm eggs deposited on the pasture with the manure will, with few exceptions, fail to develop. In either case the pasture will be almost free of infection in the spring and the main source of infection for the lambs born during the early months of the year is the adult worms harbored by the old sheep. Winter treatment with phenothiazine, either in the form of the 1 to 9 phenothiazine and salt mixture, as described on page 34, kept before the animals at all times. Treatments at appropriate times with full therapeutic doses of the drug, will also aid materially in preventing excessive parasitism in the lambs. Where the latter method of treatment is used the first dose of the drug should be administered after the sheep have been removed from the pasture in the fall and the second shortly before the sheep and their lambs go out to pasture in the spring. If the sheep are left on pasture throughout the fall and winter the times at which these treatments should be administered will depend upon local climatic conditions.

The Department of Agriculture has issued Miscellaneous Publication 25, entitled "A Calendar of Livestock Parasites," which gives directions for the control of parasites applicable to each month in the year. Every sheepman should have a copy of this calendar and consult it each month. Timely control measures prevent losses and save time, money, and labor.

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